Rules for the Classification of Yachts

Effective from 1 January 2025

Part C

Machinery, Systems and Fire Protection

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GENERAL CONDITIONS

Definitions:

Administration" means the Government of the State whose flag the ship is entitled to fly or under whose authority the ship is authorized to operate in the specific case.

"**IACS**" means the International Association of Classification Societies.

"Interested Party" means the party, other than the Society, having an interest in or responsibility for the Ship, product, plant or system subject to classification or certification (such as the owner of the Ship and his representatives, the shipbuilder, the engine builder or the supplier of parts to be tested) who requests the Services or on whose behalf the Services are requested.

"**Owner**" means the registered owner, the shipowner, the manager or any other party with the responsibility, legally or contractually, to keep the ship seaworthy or in service, having particular regard to the provisions relating to the maintenance of class laid down in Part A, Chapter 2 of the Rules for the Classification of Ships or in the corresponding rules indicated in the Specific Rules.

"**Rules**" in these General Conditions means the documents below issued by the Society:

(i) Rules for the Classification of Ships or other special units.
(ii) Complementary Rules containing the requirements for product, plant, system and other certification or containing the requirements for the assignment of additional class notations;
(iii) Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations.
(iv) Guides to carry out particular activities connected with Services;
(v) Any other technical document, for example, rule variations or interpretations.

"Services" means the activities described in paragraph 1 below, rendered by the Society upon request made by or on behalf of the Interested Party.

"**Ship**" means ships, boats, craft and other special units, for example, offshore structures, floating units and underwater craft.

"Society" or "TASNEEF" means TASNEEF Maritime

"**Surveyor**" means technical staff acting on behalf of the Society in performing the Services.

"**Force Majeure**" means damage to the ship; unforeseen inability of the Society to attend the ship due to government restrictions on right of access or movement of personnel; unforeseeable delays in port or inability to discharge cargo due to unusually lengthy periods of severe weather, strikes or civil strife; acts of war; or other force majeure.

1. Society Roles

1.1. The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:
(i) sets forth and develops Rules.
(ii) publishes the Register of Ships.
(iii) Issues certificates, statements and reports based on its survey activities.
1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various Governments.
1.3. The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which is regulated by these general conditions unless expressly excluded in the particular contract.

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2. Rule Development, Implementation and Selection of Surveyor

2.1. The Rules developed by the Society reflect the level of its technical knowledge at the time they are published therefore, the Society, although also committed through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.
2.2. The Interested Party is required to know the Rules based on which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatement. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification. The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.
2.3. Society exercises due care and skill:
(i) In the selection of its Surveyors
(ii)In the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.
2.4. Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

3. Class Report & Interested Parties Obligation

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame). The Society is under no obligation to make statements or provide information about elements or facts which are not part of the specific scope of the Service requested by the Interested Party or on its behalf.
3.2. No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as part of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorized bodies and no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties based on the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.
3.3. The classification of a Ship or the issuance of a certificate or other document connected with classification or certification and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaworthiness, structural integrity, quality or fitness for a particular purpose or service of any Ship, structure, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society about its activities reflects the condition of the Ship or the subject of certification or other activity at the time of the check.
3.5. The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, shipbuilders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, the Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.
In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.
In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third-party claim, as well as from any liability about the latter concerning the Services rendered.
Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties concerning the services rendered by the Society are described in the Rules applicable to the specific service rendered.

4. Service Request & Contract Management

4.1. Any request for the Society's Services shall be submitted in writing and signed by or on behalf of the Interested Party. Such a request will be considered irrevocable as soon as received by the Society and shall entail acceptance by the applicant of all relevant requirements of the Rules, including these General Conditions. Upon acceptance of the written request by the Society, a contract between the Society and the Interested Party is entered into, which is regulated by the present General Conditions.

4.2 In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested.

4.3 The contractor for the classification of a ship or for the services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30/60/90 days' notice, to be given in writing. Failure to pay, even in part, the fees due for services carried out by the society will entitled the society to immediately terminate the contract and suspend the service.
For every termination of the contract, the fees for the activities performed until the time of the termination shall be owned to the society as well as the expenses incurred in view of activities already programmed, this is without prejudice to the right to compensation due to the society as a consequence of the termination.
With particular reference to ship classification and certification, unless decided otherwise by the society, termination of the contract implies that the assignment of class to a ship is withheld or, if already assigned, that it is suspended or withdrawn, any statutory certificates issued by society will be withdrawn in those cases where provided for by agreements between the society and the flag state.

5. Service Accuracy

5.1. In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see **Rule Development, Implementation and Selection of Surveyor** 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.

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6. Confidentiality & Document sharing

6.1. All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorization of the Interested Party, except as provided for or required by any applicable international, European or domestic legislation, Charter or other IACS resolutions, or order from a competent authority. Information about the status and validity of class and statutory certificates, including transfers, changes, suspensions, withdrawals of class, recommendations/conditions of class, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.
Information about the status and validity of other certificates and statements may also be published on the website or released by other means, without the prior consent of the Interested Party.

6.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 below, the Society's clients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific property of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.
6.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual-class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificates, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty to ensure that, whenever required, the consent of the builder is obtained about the provision of plans and drawings to the new Society, either by way of the appropriate stipulation in the building contract or by other agreement.
In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

7. Health, Safety & Environment

7.1. The clients such as the designers, shipbuilders, manufacturers, repairers, suppliers, contractors or sub-contractors, or other product or system surveyed who have a registered office in ABU Dhabi; should have an approved OSHAD as per Abu Dhabi OHS Centre, or, if they do not need to have an approved OSHAD, they shall comply with TASNEEF standards and have procedures in place to manage the risks from their undertakings.

7.2. For the survey, audit and inspection activities onboard the ship, the ship's owner, the owner representative or the shipyard must follow TASNEEF rules regarding the safety aspects.

8. Validity of General Conditions

8.1. Should any part of these General Conditions be declared invalid, this will not affect the validity of the remaining provisions.

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9. Force Majeure

9.1 Neither Party shall be responsible to the other party for any delay or failure to carry out their respective obligations insofar as such delay and failure derives, directly or indirectly, and at any time, from force majeure of any type whatsoever that lies outside the control of either Party.

9.2 The Party that is unable to fulfil the agreement due to Force Majeure shall inform the other party without delay and in all cases within 7 days from when such force majeure arose.

9.3 It is understood that if such force majeure continues for more than 30 days, the Party not affected by the event may terminate this agreement by registered letter. The rights matured until the day in which the force majeure occurred remain unaffected.

10. Governing Law and Jurisdiction

This Agreement shall be governed by and construed in accordance with the laws of Abu Dhabi and the applicable Federal Laws of the UAE.
Any dispute arising out of or in accordance with this Agreement shall be subject to the exclusive jurisdiction of the Abu Dhabi courts.

11. Code of Business conduct

The **CLIENT** declares to be aware of the laws in force about the responsibility of the legal persons for crimes committed in their interest or to their own advantage by persons who act on their behalf or cooperate with them, such as directors, employees or agents.
In this respect, the **CLIENT** declares to have read and fully understood the "**Ethical Code**" published by **TASNEEF** and available in the **TASNEEF** Web site.
The **CLIENT**, in the relationships with **TASNEEF**, guarantees to refrain from any behaviour that may incur risk of entry in legal proceedings for crimes or offences, whose commission may lead to the enforcement of the laws above.
The **CLIENT** also acknowledges, in case of non-fulfilment of the previous, the right of **TASNEEF** to unilaterally withdraw from the contract/agreement even if there would be a work in progress situation or too early terminate the contract/agreement. It's up to **TASNEEF** to choose between the two above mentioned alternatives, and in both cases a registered letter will be sent with a brief sum-up of the circumstances or of the legal procedures proving the failure in following the requirements of the above-mentioned legislation.

In light of the above, it is forbidden to all employees and co-operators to:
- receive any commission, percentage or benefits of any possible kind;
- Start and maintaining any business relationship with **Clients** that could cause conflict of interests with their task and function covered on behalf of **TASNEEF.**
- Receive gifts, travel tickets or any other kind of benefits different from monetary compensation, that could exceed the ordinary business politeness.

Violation of the above-mentioned principles allows **TASNEEF** to early terminate the contract and to be entitled to claim compensation for losses if any.

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EXPLANATORY NOTE TO PART C

1. Reference edition

The reference edition for Part C is the Rules for Yachts 2024 edition, which is effective from 1 July 2024.

2. Amendments after the reference edition

2.1 Rules for Yachts 2024 has been completely rewritten and reorganised.

2.2 Except in particular cases, the Rules are updated and published annually.

3. Effective date of the requirements

3.1 All requirements in which new or amended provisions with respect to those contained in the reference edition have been introduced are followed by a date shown in brackets.

The date shown in brackets is the effective date of entry into force of the requirements as amended by the last updating. The effective date of all those requirements not followed by any date shown in brackets is that of the reference edition.

3.2 Item 6 below provides a summary of the technical changes from the preceding edition. In general, this list does not include those items to which only editorial changes have been made not affecting the effective date of the requirements contained therein.

4. Rule Variations and Corrigenda

Until the next edition of the Rules is published, Rule Variations and/or corrigenda, as necessary, will be published on the Tasneef web site (www.tasneef.ae). Except in particular cases, paper copies of Rule Variations or corrigenda are not issued.

5. Rule subdivision and cross-references

5.1 Rule subdivision

The Rules are subdivided into six parts, from A to F.

Part A: Classification and Surveys

Part B: Hull and Stability

Part C: Machinery, Systems and Fire Protection

Part D: Materials and Welding

Part E: Service Notations

Part F: Additional Class Notations

Each Part consists of:

- Chapters
- Sections and possible Appendices
- Articles
- Sub-articles
- Requirements

Figures (abbr. Fig) and Tables (abbr. Tab) are numbered in ascending order within each Section or Appendix.

5.2 Cross-references

Examples: Pt A, Ch 1, Sec 1, [3.2.1]or Pt A, Ch 1, App 1, [3.2.1]

- Pt A means Part A

The part is indicated when it is different from the part in which the cross-reference appears. Otherwise, it is not indicated.

- Ch 1 means Chapter 1

The Chapter is indicated when it is different from the chapter in which the cross-reference appears. Otherwise, it is not indicated.

- Sec 1 means Section 1 (or App 1 means Appendix 1)

The Section (or Appendix) is indicated when it is different from the Section (or Appendix) in which the cross-reference appears. Otherwise, it is not indicated.

- [3.2.1] refers to requirement 1, within sub-article 2 of article 3.

Cross-references to an entire Part or Chapter are not abbreviated as indicated in the following examples:

- Part A for a cross-reference to Part A
- Part A, Chapter 1 for a cross-reference to Chapter 1 of Part A.

RULES FOR THE CLASSIFICATION OF YACHTS

Part C
Machinery, Systems and Fire Protection

Chapters **1 2 3 4**

CHAPTER 1 MACHINERY

Section 1 General Requirements

Section 2 Diesel Engines

Section 3 Gas Turbines

Section 4 Yachts Fuelled with Alternative Fuels

Section 5 Pressure Vessels

Section 6 Gearing

Section 7 Main Propulsion Shafting

Section 8 Propellers

Section 9 Shaft Vibration

Section 10 Piping System

Section 11 Steering

Section 12 Thruster

Section 13 Refrigerating Installations

Section 14 Turbochargers

Section 15 Anchor Windlass

Section 16 Tests on Board

Appendix 1 Alternatives, Relaxations and Additional Considerations for Yachts of less than 500 GT

Appendix 2 Alternatives, Relaxations and Additional Considerations for Yachts of less than 24 m LLL

Appendix 3 Plastic Pipes

Appendix 4 Installation of Ballast Water Management Systems

CHAPTER 2 ELECTRICAL INSTALLATIONS

Section 1 General

Section 2 General Design Requirements

Section 3 System Design

Section 4 Rotating Machines

Section 5 Transformers

Section 6 Semiconductor Convertors

Section 7 Storage Batteries, Chargers, Uninterruptible Power Systems and Fuel Cells

Section 8 Switchgear and Controlgear Assemblies

Section 9 Cables

Section 10 Miscellaneous Equipment

Section 11 Location

Section 12 Installation

Section 13 High Voltage Installations

Section 14 Electric Propulsion Plant

Section 15 Testing

Appendix 1 Alternatives, Relaxations and Additional Considerations for yachts of less than 500GT

Appendix 2 Alternatives, Relaxations and Additional Considerations for yachts of less than 24m LLL

Appendix 3 Detail of Documentation to be Submitted

Appendix 4 Battery Powered Yachts

Appendix 5 Fuel Cell Powered Yachts

CHAPTER 3 AUTOMATION

Section 1 General

Section 2 Design Requirements

Section 3 Computer Based Systems

Section 4 Constructional Requirements

Section 5 Installation Requirements

Section 6 Testing

Appendix 1 Alternatives, Relaxations and Additional Considerations for yachts of less than 500GT

Appendix 2 Alternatives, Relaxations and Additional Considerations for yachts of less than 24m LLL

Appendix 3 Guidance for the Application of Section 3 on Computer Based Systems

CHAPTER 4 FIRE PROTECTION, DETECTION AND EXTINCTION

Section 1 General Requirements

Section 2 Fire Prevention

Section 3 Fire Containment

Section 4 Fire Detection

Section 5 Means of Escape

Section 6 Protection of Spaces Containing Vehicles or Craft with Fuel in their Tanks or Lockers Storing Such Fuels

Section 7 REFUEL STATION LOCATED INSIDE A GARAGE CONTAINING VEHICLES OR CRAFTS WITH FUEL IN THEIR TANKS

Section 8 Fire Applications

Section 9 Helideck Facilities

Appendix 1 Alternatives, Relaxations and Additional Considerations for yachts below 500 GT

Appendix 2 Alternatives, Relaxations and Additional Considerations for yachts of less than 24m LLL

Appendix 3 Open Flame Gas Installations

Appendix 4 Fixed Gas Fire-Extinguishing System Additional Requirements

Chapter 1

MACHINERY

SECTION 1 GENERAL REQUIREMENTS

1 General

1.1 Application

1.1.1 Chapter 1 applies to the design, construction, installation, tests and trials of main propulsion and essential auxiliary machinery systems and associated equipment, boilers and pressure vessels, piping systems, and steering and manoeuvring systems installed on board classed yachts, as indicated in each Section of this Chapter.

1.2 Additional requirements

1.2.1 Additional requirements for machinery are given in Part F, for the assignment of additional class notations.

1.3 Documentation to be submitted

1.3.1 Before the actual construction is commenced, the Manufacturer, Designer or Shipbuilder is to submit to the Society the documents (plans, diagrams, specifications and calculations) requested in the relevant Sections of this Chapter.

The list of documents requested in each Section is to be intended as guidance for the complete set of information to be submitted, rather than an actual list of titles.

The Society reserves the right to request the submission of additional documents to those detailed in the Sections, in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or component.

Plans are to include all the data necessary for their interpretation, verification and approval.

In any case, the Society reserves the rights to require additional information when deemed necessary.

1.4 Definitions

1.4.1 Machinery spaces of Category A

Machinery spaces of Category A are those spaces and trunks to such spaces which contain:

- internal combustion machinery used for main propulsion, or
- 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 fuel oil unit, or
- gas generators, incinerators, waste disposal units, etc., which use oil fired equipment.

1.4.2 Machinery spaces

Machinery spaces are all machinery spaces of Category A and all other spaces containing propulsion machinery, boilers, fuel oil units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

1.4.3 Fuel oil unit

Fuel oil unit is the equipment used for the preparation of fuel oil for delivery to an oil fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0,18 N/mm^2.

For the purpose of this definition, inert gas generators are to be considered as oil fired boilers and gas turbines are to be considered as internal combustion engines.

1.4.4 Dead Ship condition

Dead Ship condition is the condition under which the whole propulsion system, including the main power supply, is not in operation and auxiliary means for bringing the main propulsion machinery into operation and for the restoration of the main power supply, such as compressed air and starting current from batteries, are not available, but assuming that means are available to start the emergency generator at all times.

2 Design and construction

2.1 General

2.1.1 The machinery and pressure vessels, associated piping systems and fittings are to be of a design and construction adequate for the service for which they are intended and shall be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards.

The design is to have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

2.2 Materials, welding and testing

2.2.1 General

Materials, welding and testing procedures are to be in accordance with the requirements of Part D and those given in the other Sections of this Chapter. In addition, for machinery components fabricated by welding the requirements given in [2.2.2] apply.

2.2.2 Welded machinery components

Welding processes and welders are to be approved by the Society in accordance with Part D, Chapter 5.

References to welding procedures adopted are to be clearly indicated on the plans submitted for approval.

Joints transmitting loads are to be either:

- full penetration butt-joints welded on both sides, except when an equivalent procedure is approved
- full penetration T- or cruciform joints.

For joints between plates having a difference in thickness greater than 3 mm, a taper having a length of not less than 4 times the difference in thickness is required. Depending on the type of stress to which the joint is subjected, a taper equal to three times the difference in thickness may be accepted.

T-joints on scalloped edges are not permitted.

Lap-joints and T-joints subjected to tensile stresses are to have a throat size of fillet welds equal to 0,7 times the thickness of the thinner plate on both sides.

In the case of welded structures including cast pieces, the latter are to be cast with appropriate extensions to permit connection, through butt-welded joints, to the surrounding structures, and to allow any radiographic and ultrasonic examinations to be easily carried out.

Where required, preheating and stress relieving treatments are to be performed according to the welding procedure specification.

2.3 Vibrations

2.3.1 Special consideration is to be given to the design, construction and installation of propulsion machinery systems and auxiliary machinery so that any mode of their vibrations shall not cause undue stresses in this machinery in the normal operating ranges.

2.4 Operation in inclined position

2.4.1 Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the yacht are, as fitted in the yacht, be designed to operate when the yacht is upright and when inclined at any angle of list either way and trim by bow or stern as stated in Tab 1.

The Society may permit deviations from angles given in Tab 1, taking into consideration the type, size and service conditions of the yacht.

Machinery with a horizontal rotation axis is generally to be fitted on board with such axis arranged alongship. If this is not possible, the Manufacturer is to be informed at the time the machinery is ordered.

2.5 Ambient conditions

2.5.1 Machinery and systems covered by the Rules are to be designed to operate properly under the ambient conditions specified in Tab 2, unless otherwise specified in each Section of this Chapter.

2.6 Power of machinery

2.6.1 Unless otherwise stated in each Section of this Chapter, where scantlings of components are based on power, the values to be used are determined as follows:

- for main propulsion machinery, the power/rotational speed for which classification is requested
- for auxiliary machinery, the power/rotational speed which is available in service.

2.7 Astern power

2.7.1 Sufficient power for going astern is to be provided to secure proper control of the in all normal circumstances.

The main propulsion machinery is to be capable of maintaining in free route astern at least 70% of the maximum ahead revolutions for a period of at least 30 min.

Table 1 : Inclination of yacht

Installations, components	Angle of inclination (degrees) **(1)**			
	Athwartship		Fore and aft	
	static	dynamic	static	dynamic
Main and auxiliary machinery	15	22,5	5 (3)	7,5
Safety equipment, e.g. emergency power installations, emergency fire pumps and their devices Switch gear, electrical and electronic appliances (2) and remote control systems	22,5	22,5	10	10

(1) Athwartship and fore-and-aft inclinations may occur simultaneously.
(2) No undesired switching operations or operational changes are to occur.
(3) Where the length yacht of the exceeds 100m, the fore-and-aft static angle of inclination may be taken as 500/L degrees, where L is the length of the yacht in metres, as defined in Pt B.

Table 2 : Ambient conditions

AIR TEMPERATURE	
Location, arrangement	Temperature range (°C)
In enclosed spaces	between 0 and +45 **(2)**
On machinery components, boilers In spaces subject to higher or lower temperatures	According to specific local conditions
On exposed decks	between -25 and +45 **(1)**

WATER TEMPERATURE	
Coolant	Temperature (°C)
Sea water or, if applicable, sea water at charge air coolant inlet	up to +32

(1) Electronic appliances are to be designed for an air temperature up to 55°C (for electronic appliances see also Chapter 2).
(2) Different temperatures may be accepted by the Society in the case of s intended for short range.

For main propulsion systems with reversing gears, controllable pitch propellers or electrical propeller drive, running astern is not to lead to an overload of propulsion machinery.

During the sea trials, the ability of the main propulsion machinery to reverse the direction of thrust of the propeller is to be demonstrated and recorded (see also Sec 16).

2.8 Safety devices

2.8.1 Where risk from overspeeding of machinery exists, means are to be provided to ensure that the safe speed is not exceeded.

2.8.2 Where main or auxiliary machinery including pressure vessels or any parts of such machinery are subject to internal pressure and may be subject to dangerous overpressure, means shall be provided, where practicable, to protect against such excessive pressure.

2.8.3 Main turbine propulsion machinery and, where applicable, main internal combustion propulsion machinery and auxiliary machinery shall be provided with automatic shut-off arrangements in the case of failures, such as lubricating oil supply failure, which could lead rapidly to complete breakdown, serious damage or explosion.

The Society may permit provisions for overriding automatic shut-off devices.

See also the specific requirements given in the other Sections of this Chapter.

2.9 Fuels

2.9.1

Fuel oils employed for engines and boilers are, in general, to have a flash point (determined using the closed cup test) of not less than 60°C. However, for engines driving emergency generators, fuel oils having a flash point of less than 60°C but not less than 43°C are acceptable.

The use of fuel oil having a flashpoint of less than 60º C but not less than 43º C may be permitted (e.g. for feeding the emergency fire pump's engines and auxiliary machines which are not located in category A machinery spaces) subject to the following:

- fuel oil tanks except those arranged in double bottom compartments are located outside of category A machinery spaces;
- provisions for the measurement of oil temperature are provided on the suction pipe of the fuel oil pump;
- stop valves and/or cocks are provided on the inlet side and outlet side of the fuel oil strainers; and
- pipe joints of welded construction or of circular cone type or spherical type union joint are applied as far as possible.

Fuel oil having flash points of less than 43°C may be employed on board provided that it is stored outside machinery spaces and the arrangements adopted are specially approved by the Society.

The use of liquefied or compressed natural gas as fuel is allowed on yachts subject to the specific requirements given in App 7 of Tasneef Rules for The Classification of Ships or on yachts in compliance with the latest edition of the International Code of Safety for s Using Gases or Other Low-Flashpoint Fuels (IGF Code), as amended, or equivalent arrangements. The use of LPG or NH_3 as fuel is allowed subject to the specific requirements given in App 13 of Tasneef Rules for The Classification of Ships. The use of hydrogen as fuel is allowed subject to the specific requirements given in App 14 of Tasneef Rules for The Classification of Ships. The use of methyl/ethyl alcohol as fuel is allowed subject to the specific requirements given in App 15 of Tasneef Rules for The Classification of Ships. The use of biofuel as fuel is allowed subject to the specific requirements given in App 16 of Tasneef Rules for The Classification of Ships . The use of other gases as fuel is considered by the Society on a case-by-case basis.

Note 1: The use of gas as fuel in s requires additional acceptance by the Administration of the State whose flag the yacht is entitled to fly.

2.10 Use of asbestos

2.10.1

New installation of materials which contain asbestos is prohibited.

3 Arrangement and installation on board

3.1 General

3.1.1 Provision shall be made to facilitate cleaning, inspection and maintenance of main propulsion and auxiliary machinery, including boilers and pressure vessels.

Easy access to the various parts of the propulsion machinery is to be provided by means of metallic ladders and gratings fitted with strong and safe handrails.

Spaces containing main and auxiliary machinery are to be provided with adequate lighting and ventilation.

3.2 Floors

3.2.1 Floors in engine rooms are to be metallic, divided into easily removable panels.

3.3 Bolting down

3.3.1 Bedplates of machinery are to be securely fixed to the supporting structures by means of foundation bolts which are to be distributed as evenly as practicable and of a sufficient number and size so as to ensure a perfect fit.

Where the bedplates bear directly on the inner bottom plating, the bolts are to be fitted with suitable gaskets so as to ensure a tight fit and are to be arranged with their heads within the double bottom.

Continuous contact between bedplates and foundations along the bolting line is to be achieved by means of chocks of suitable thickness, carefully arranged to ensure a complete contact.

The same requirements apply to thrust block and shaft line bearing foundations.

Particular care is to be taken to obtain a perfect levelling and general alignment between the propulsion engines and their shafting (see Sec 7).

3.3.2 Chocking resins are to be type approved with reference to Pt A, Ch 2, App.3.

3.4 Safety devices on moving parts

3.4.1 Suitable protective devices are to be provided in way of moving parts (flywheels, couplings, etc.) in order to avoid injuries to personnel.

3.5 Gauges

3.5.1 All gauges are to be grouped, as far as possible, near each manoeuvring position; in any event, they are to be clearly visible.

3.6 Ventilation in machinery spaces

3.6.1

Machinery spaces of category A are to be sufficiently ventilated so as to ensure that when machinery or boilers therein are operating at full power in all weather conditions, including heavy weather, an adequate supply of air is maintained to the spaces for the safety and comfort of personnel and the operation of the machinery.

Any other machinery space shall be adequately ventilated in relation to the purpose of that machinery space.

This sufficient amount of air is to be supplied through suitably protected openings arranged in such a way that they can be used in all weather conditions.

Special attention is to be paid both to air delivery and extraction and to air distribution in the various spaces. The quantity and distribution of air are to be such as to satisfy machinery requirements for developing maximum continuous power.

The ventilation is to be so arranged as to prevent any accumulation of flammable gases or vapours.

The requirements of the engine Manufacturer are to be complied with.

3.7 Hot surfaces and fire protection

3.7.1

Surfaces, having temperature exceeding 60°C, with which the crew are likely to come into contact during operation are to be suitably protected or insulated.

Surfaces of machinery with temperatures above 220°C, e.g. steam, thermal oil and exhaust gas lines, silencers, exhaust gas boilers and turbochargers, are to be effectively insulated with non-combustible material or equivalently protected to prevent the ignition of combustible materials coming into contact with them. Where the insulation used for this purpose is oil absorbent or may permit the penetration of oil, the insulation is to be encased in steel sheathing or equivalent material.

The insulation of hot surfaces is to be of a type and so supported that it does not crack or deteriorate when subject to vibration.

Fire protection, detection and extinction is to comply with the requirements of Chapter 4.

3.8 Communications

3.8.1 At least two independent means are to be provided for communicating orders from the navigating bridge to the position in the machinery space or in the control room from which the speed and the direction of the thrust of the propellers are normally controlled; one of these is to be an engine room telegraph, which provides visual indication of the orders and responses both in the machinery space and on the navigating bridge, with audible alarm mismatch between order and response.

Appropriate means of communication shall be provided from the navigating bridge and the engine room to any other position from which the speed and direction of thrust of the propellers may be controlled.

The second means for communicating orders is to be fed by an independent power supply and is to be independent of other means of communication.

Where the main propulsion system of the yacht is controlled from the navigating bridge by a remote control system, the second means of communication may be the same bridge control system.

The engine room telegraph is required in any case, even if the remote control of the engine is foreseen, irrespective of whether the engine room is attended.

For s assigned with a short range navigation notation these requirements may be relaxed at the Society’s discretion.

3.9 Machinery remote control, alarms and safety systems

3.9.1 For remote control systems of main propulsion machinery and essential auxiliary machinery and relevant alarms and safety systems, the requirements of Chapter 3 apply.

3.9.2 An engineers’ alarm shall be provided to be operated from the engine control room or at the manoeuvring platform as appropriate, and shall be clearly audible in the engineers’ accommodation.

4 Tests and trials

4.1 Works tests

4.1.1 Equipment and its components are subjected to works tests which are detailed in the relevant Sections of this Chapter and are to be witnessed by the Surveyor.

Where such tests cannot be performed in the workshop, the Society may allow them to be carried out on board, provided this is not judged to be in contrast either with the general characteristics of the machinery being tested or with particular features of the shipboard installation. In such cases, the Surveyor entrusted with the acceptance of machinery on board and the purchaser are to be informed in advance and the tests are to be carried out in accordance with the provisions of Part D relative to incomplete tests.

All boilers, all parts of machinery, all steam, hydraulic, pneumatic and other systems and their associated fittings which are under internal pressure shall be subjected to appropriate tests including a pressure test before being put into service for the first time as detailed in the other Sections of this Chapter.

4.2 Trials on board

4.2.1 Trials on board of machinery are detailed in Sec 16.

SECTION 2 DIESEL ENGINES

1 General

1.1 Application

1.1.1 *(1/1/2025)*

Diesel engines listed below are to be designed, constructed, installed, tested and certified in accordance with the requirements of this Section, under the supervision and to the satisfaction of the Society's Surveyors and in accordance with the relevant Table of Pt A, Ch 2, App 3:

a) main propulsion engines

b) engines driving electrical generators and other auxiliaries essential for safety and navigation, when they develop a power of 110 kW and over.

All other engines are to be designed and constructed according to sound marine practice, with the equipment required in [4.3.4], [4.5.2], [4.7.2] [4.7.3], [4.7.5] and [4.7.8] and delivered with the relevant works' certificate (see Pt D, Ch 1, Sec 1, [4.2.3]).

Additional requirements for control and safety systems for dual fuel engines supplied with high pressure methane gas are given in App 2 of Tasneef Rules for the Classification of Ships.

Additional requirements for internal combustion engines supplied with low pressure natural gas are given in App 12 and App 17 of Tasneef Rules for the Classification of Ships.

In addition to the requirements of this Section, those given in Sec 1 apply.

1.2 Type approval certificate

1.2.1

For each type of engine that is required to be certified, a type approval certificate is to be obtained by the engine designer.

The type approval process consists of:

- drawing and specification approval,
- conformity of production,
- approval of type testing programme,
- type testing of engines,
- review of the obtained type testing results,
- evaluation of the manufacturing arrangements,
- issue of a type approval certificate upon satisfactorily meeting the Rule requirements.

1.3 Engine certificate

1.3.1

Each diesel engine manufactured for a shipboard application per [1.1.1] is to have an engine certificate:

The certification process consists of:

- the engine builder/licensee obtaining design approval of the engine application specific documents, if any, by submitting a comparison list of the production drawings to the previously approved engine design drawings referenced in [1.2.1]
- forwarding the relevant production drawings and comparison list for the use of the Surveyors at the manufacturing plant and shipyard if necessary
- engine's components testing and engine works trials
- the issuance of an engine certificate upon satisfactorily meeting the Rule requirements.

1.4 Documentation

1.4.1 Document flow for obtaining a type approval certificate

a) For the initial engine type, the engine designer is to submit to the Society the documentation in accordance with requirements in Tab 1 and Tab 2.

b) Upon review and approval of the submitted documentation (evidence of approval), it will be re-turned to the engine designer.

c) The engine designer arranges for a Surveyor to attend an engine type test

d) Upon satisfactory testing and examination of relevant reports, the Society issues a type approval certificate.

1.4.2 Document flow for engine certificate

a) The engine type must have a type approval certificate. For the first engine of a type, process and the engine certification process (ECP) may be performed simultaneously.

b) Engines to be installed in specific applications may require the engine designer/licensor to modify the design or performance requirements. The modified drawings are forwarded by the engine designer to the engine builder/licensee to develop production documentation for use in the engine manufacture in accordance with Tab 3.

c) The engine builder/licensee develops a comparison list of the production documentation to the documentation listed in Tab 1 and Tab 2. An example comparison list is provided in App 10 of Tasneef Rules for the Classification of Ships. If there are differences in the technical content on the licensee's production drawings/documents compared to the corresponding licensor's drawings, the licensee must obtain agreement to such differences from the designer using the template in App 11 of Tasneef Rules for the classification of Ships.

   If the designer agreement is not confirmed, the engine is to be regarded as a different engine type and is to be subjected to the complete type approval process by the licensee.

d) The engine builder/licensee is to submit the comparison list and the production documentation to the Society review/approval.

e) The reviewed/approved documentation is to be used by the engine builder/licensee and their subcontractors and attending Surveyors. The attending Surveyors may request the engine builder/licensee or their subcontractors to provide the actual documents indicated in the list, in which case these are to be made available for the Surveyors.

f) The attending Surveyors, at the engine builder/licensee/subcontractors, will issue product certificates as necessary for components manufactured upon satisfactory inspections and tests.

g) The engine builder/licensee assembles the engine, tests the engine with a Surveyor present.

h) An engine certificate is issued by the Surveyor upon satisfactory completion of assembly and tests.

1.5 Definitions

1.5.1 Engine type

A type of engine is defined:

- bore and stroke
- injection method (direct or indirect)
- valve and injection operation (by cams or electronically controlled)
- kind of fuel (liquid, dual-fuel, gaseous)
- working cycle (4-stroke, 2-stroke)
- turbo-charging system (pulsating or constant pressure)
- the charging air cooling system (e.g. with or without intercooler)
- cylinder arrangement (in-line or V)
- cylinder power, speed and cylinder pressures.

1.5.2 Ambient reference conditions

The power of engines as per [1.1.1] (a), and (b) is to be referred to the following ambient reference conditions:

- barometric pressure = 0,1 MPa
- relative humidity = 60%
- ambient air temperature = 45°
- sea water temperature (and temperature at inlet of sea water cooled charge air cooler) = 32°C.

In the case of yachts with short range navigation, different temperatures may be accepted by the Society.

The engine Manufacturer is not expected to provide the above ambient conditions at a test bed. The rating is to be adjusted according to a recognized standard accepted by the Society.

1.5.3 Engine power

The maximum continuous power is the maximum power at ambient reference conditions [1.5.2] which the engine is capable of delivering continuously, at nominal maximum speed, in the period of time between two consecutive overhauls.

Power, speed and the period of time between two consecutive overhauls are to be stated by the Manufacturer and agreed by the Society.

The rated power is the maximum power at ambient reference conditions [1.5.2] which the engine is capable of delivering as set after works trials (fuel stop power) at the maximum speed allowed by the governor.

The rated power for engines driving electric generators is the nominal power, taken at the net of overload, at ambient reference conditions [1.5.2], which the engine is capable of delivering as set after the works trials [7.4].

1.5.4 Society Certificate (SC)

This is a document issued by the Society stating:

- conformity with Rule requirements,
- that the tests and inspections have been carried out on:
  - the finished certified component itself; or
  - on samples taken from earlier stages in the production of the component, when applicable,
- that the inspection and tests were performed in the presence of the Surveyor or in accordance with special agreements, i.e. Alternative Certification Scheme (ACS).

1.5.5 Work’s Certificate (W)

This is a document signed by the manufacturer stating:

- conformity with requirements
- that the tests and inspections have been carried out on:
  - the finished certified component itself; or
  - on samples taken from earlier stages in the production of the component, when applicable,
- that the tests were witnessed and signed by a qualified representative of the applicable department of the manufacturer.

A Work's Certificate may be considered equivalent to a Society Certificate and endorsed by the Society if:

- the test was witnessed by the Society Surveyor; or
- an ACS agreement is in place between the Class Society and the manufacturer or material supplier; or
- the Work's certificate is supported by tests carried out by an accredited third party that is accepted by the Society and independent from the manufacturer and/or material supplier.

1.5.6 Test Report (R)

This is a document signed by the manufacturer stating:

- conformity with requirements
- that the tests and inspections have been carried out on samples from the current production batch.

1.5.7

Low-Speed Engines means diesel engines having a rated speed of less than 300 rpm.

1.5.8

Medium-Speed Engines means diesel engines having a rated speed of 300 rpm and above, but less than 1400 rpm.

1.5.9

High-Speed Engines means diesel engines having a rated speed of 1400 rpm or above.

1.6 Light and Medium Duty

1.6.1 Operative profile *(1/1/2025)*

The yachts with limited use of machinery may have engines certified for one of the following operative profiles:

- light duty
- medium duty

The operative profile is determined by means of the specification of the following parameters: :

- $O_{A\,MAX}$, maximum number of running hours per year expected for the yacht;
- $O_{P\,MAX}$, maximum number of running hours per year expected for the vessel with the main engines running at maximum power;

The engines have to be capable of:

- delivering the maximum power, at nominal maximum speed, for a number of running hours per year ($O_{A\,MAX}$) in the range defined below ,

- being capable to operate, even not continuously at themaximum power, for a number of running hours per year ($O_{P\,MAX}$) in the range defined below

- Light duty: 1000 <= $O_{A\,MAX}$ >= 3000 hours, 100 <=$O_{P\,MAX}$ >= 750 hours
- Medium duty: $O_{A\,MAX}$ >= 3000 hours, $O_{P\,MAX}$ >= 750 hours

Light duty and medium duty engines are not required to be capable to sustain overload power.

The maximum and continuous power, speed and the period of time between two consecutive overhauls are to be stated by the Manufacturer and agreed by the Society. Manufacturer is also required to provide a complete and detailed operative profile of the engine with the indication of every limitation at intermediate powers.

1.6.2 Light duty e medium duty engines *(1/1/2025)*

In yachts with light duty or medium duty operating profile, ad defined in [1.6.1] engines set for intermittent duty which maximum power P_{MAX} will be defined by the Manufacturer according to the parameters O_{AMAX} e O_{PMAX} and Ic defined in this paragraph, may be installed. The maximum speed and the period between the two subsequent maintenances are to be established by the Manufacturer and accepted by the Society.

For light and medium duty the parameters in addition to those in [1.6.1] are respectively:

- Light duty: I_C >= 0,4, $O_{A\,MIN}$ = 1000 hours
- Medium duty: I_C >=0,6 $O_{A\,MIN}$ = 3000 hours

Such engines are to be approved according to [6.12.1] and [6.12.2] and individually tested when required in Pt A Ch 2 App 3.

2 Type approval process

2.1

2.1.1

The type approval process consists of the steps in [2.2] to [2.5].

The documentation, as far as applicable to the type of engine, to be submitted by the engine design-er/licensor is listed in Tab 1 and Tab 2.

2.2 Documentation for information Table 1

2.2.1

Tab 1 lists basic descriptive information required to be submitted to provide an overview of the engine's design, engine characteristics and performance.

2.3 Documentation for approval or recalculation Table 2

2.3.1

Tab 2 lists the documents and drawings, which are to be submitted for approval.

2.4 Design approval (DA)

2.4.1

DA's are valid as long as no substantial modifications have been implemented. Where substantial modifications have been made the validity of the DA's may be renewed based on evidence that the design is in conformance with all current Rules and statutory regulations (e.g. SOLAS, MARPOL). See also [4.6].

2.5 Type approval test

2.5.1

A type approval test is to be carried out in accordance with [6] and is to be witnessed by the Classification Society.

The manufacturing facility of the engine presented for the type approval test is to be assessed in accordance with [7.1].

2.6 Type approval certificate

2.6.1

After the requirements in [2.2] to [2.5] have been satisfactorily completed the Classification Society issues a type approval certificate (TAC).

2.7 Design modifications

2.7.1

After the Classification Society has approved the engine type for the first time, only those documents as listed in the tables, which have undergone substantive changes, will have to be resubmitted for consideration by the Classification Society.

2.7.2

Where changes are proposed to be carried out to a type approved engine, if the responsible party submits to the Society for consideration and/or approval those documents concerning the engine parts which have undergone changes and the proposed modifications are evaluated by the Society as non-substantial, the type approval may be considered as extended to the modified engine without a new type test.

2.8 Type approval certificate renewals

2.8.1

A renewal of a Design Approval (DA) certificate will be granted upon.

Submission of information in either a) or b).

a) The submission of modified documents or new documents with substantial modifications replacing former documents compared to the previous sub-mission(s) for DA.

b) A declaration that no substantial modifications have been applied since the last DA issued.

2.9 Validity of type approval certificate

2.9.1

The Society reserves the right to limit the duration of validity of the type approval certificate. The type approval certificate will be invalid if there are substantial modifications in the design, in the manufacturing or control processes or in the characteristics of the materials unless approved in advance by the Society.

2.10 Document review and approval

2.10.1

The assignment of documents to Tab 1 for information does not preclude possible comments by the Society.

2.10.2

Where considered necessary, the Society may request further documents to be submitted. This may include details or evidence of existing type approval or proposals for a type testing program in accordance with [6].

3 Certification process

3.1

3.1.1

The certification process consists of the steps in [3.2] to [3.7].

For those cases when a licensor - licensee agreement does NOT apply, an "engine designer" shall be understood as the entity that has the design rights for the engine type or is delegated by the entity having the design rights to modify the design.

The documents listed in Tab 3 may be submitted by:

- the engine designer (licensor),
- the manufacturer/licensee.

3.2 Document development for production

3.2.1

Prior to the start of the engine certification process, a design approval is to be obtained per [2.2] through [2.4] for each type of engine. Each type of engine is to be provided with a type approval certificate obtained by the engine designer/licensor prior to the engine builder/licensee beginning production manufacturing. For the first engine of a type, the type approval process and the certification process may be performed simultaneously.

The engine designer/licensor reviews the documents listed in Tab 1 and Tab 2 for the application and develops, if necessary, application specific documentation for the use of the engine builder/licensee in developing engine specific production documents.

If substantive changes have been made, the affected documents are to be resubmitted to the Classification Society as per [2.7].

3.3 Documents to be submitted for inspection and testing

3.3.1

[2.7] lists the production documents, which are to be submitted by the engine builder/licensee to the Classification Society following acceptance by the engine designer/licensor. The Surveyor uses the information for inspection purposes during manufacture and testing of the engine and its components. See [3.3] through [3.6].

3.4 Alternative execution

3.4.1

If there are differences in the technical content on the licensee's production drawings/documents compared to the corresponding licensor's drawings, the licensee must provide to the Society a "Confirmation of the licensor's acceptance of licensee's modifications" approved by the licensor and signed by licensee and licensor. Modifications applied by the licensee are to be provided with appropriate quality requirements.

3.5 Manufacturer approval

3.5.1

The Classification Society assesses conformity of production with the Classification Society's requirements for production facilities comprising manufacturing facilities and processes, machining tools, quality assurance, testing facilities, etc. See [7.1] Satisfactory conformance results in the issue of a class approval document.

3.6 Document availability

3.6.1

In addition to the documents listed in Tab 3, the engine builder/licensee is to be able to provide to the Surveyor performing the inspection upon request the relevant detail drawings, production quality control specifications and acceptance criteria. These documents are for supplemental purposes to the survey only.

3.7 Engine assembly and testing

3.7.1

Engine assembly and testing procedure are to be carried out under survey of a Society surveyor unless an Alternative Certification Scheme is agreed between manufacturer and the Society.

Table 1 : Documentation to be submitted for information, as applicable

No.	Item
1	Engine particulars (e.g. Data sheet with general engine information (see App 9 of Tasneef Rules for the Classification of Ships), Project Guide, Marine Installation Manual)
2	Engine cross section
3	Engine longitudinal section
4	Bedplate and crankcase of cast design
5	Thrust bearing assembly **(1)**
6	Frame/framebox/gearbox of cast design **(2)**
7	Tie rod
8	Connecting rod
9	Connecting rod, assembly **(3)**
10	Crosshead, assembly
11	Piston rod, assembly **(3)**
12	Piston, assembly **(3)**
13	Cylinder jacket/ block of cast design **(2)**
14	Cylinder cover, assembly **(3)**
15	Cylinder liner
16	Counterweights (if not integral with crankshaft), including fastening
17	Camshaft drive, assembly **(3)**
18	Flywheel
19	Fuel oil injection pump
20	Shielding and insulation of exhaust pipes and other parts of high temperature which may be impinged as a result of a fuel system failure, assembly
	For electronically controlled engines, construction and arrangement of:
21	• Control valves
22	• High-pressure pumps
23	• Drive for high pressure pumps
24	Operation and service manuals **(4)**
25	FMEA (for engine control system) **(5)**
26	Production specifications for castings and welding (sequence)
27	Evidence of quality control system for engine design and in service maintenance
28	Evidence of quality control system for engine design and in service maintenance
29	Type approval certification for environmental tests, control components **(6)**

(1) If integral with engine and not integrated in the bedplate.
(2) Only for one cylinder or one cylinder configuration.
(3) Including identification (e.g. drawing number) of components.
(4) Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
(5) Where engines rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves, a failure mode and effects analysis (FMEA) is to be submitted to demonstrate that failure of the control system will not result in the operation of the engine being degraded beyond acceptable performance criteria for the engine.
(6) Tests are to demonstrate the ability of the control, protection and safety equipment to function as intended under the specified testing conditions per Ch 3, Sec 6.

Table 2 : Documentation to be submitted for approval, as applicable

No.	Item
1	Bedplate and crankcase of welded design, with welding details and welding instructions **(1)**, **(2)**
2	Thrust bearing bedplate of welded design, with welding details and welding instructions **(1)**
3	Bedplate/oil sump welding drawings
4	Frame/framebox/gearbox of welded design, with welding details and instructions **(1)**, **(2)**
5	Engine frames, welding drawings **(1)**, **(2)**
6	Crankshaft, details, each cylinder No.
7	Crankshaft, assembly, each cylinder No.
8	Crankshaft calculations (for each cylinder configuration) according to App 9 App 12 of Tasneef Rules for the Classification of Ships
9	Thrust shaft or intermediate shaft (if integral with engine)
10	Shaft coupling bolts
11	Material specifications of main parts with information on non-destructive material tests and pressure tests
	Schematic layout or other equivalent documents on the engine of:
12	• Starting air system
13	• Fuel oil system
14	• Lubricating oil system
15	• Cooling water system
16	• Hydraulic system
17	• Hydraulic system (for valve lift)
18	• Engine control and safety system
19	Shielding of high pressure fuel pipes, assembly **(4)**
20	Construction of accumulators (for electronically controlled engine)
21	Construction of common accumulators (for electronically controlled engine)
22	Arrangement and details of the crankcase explosion relief valve **(5)**
23	Calculation results for crankcase explosion relief valves
24	Details of the type test program and the type test report) **(7)**
25	High pressure parts for fuel oil injection system **(6)**
26	Oil mist detection and/or alternative alarm arrangements
27	Details of mechanical joints of piping systems (see Sec 10)
28	Documentation verifying compliance with inclination limits (see Sec 1)
29	Documents as required in Ch 3, Sec 3 as applicable

(1) For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.
(2) For each cylinder for which dimensions and details differ.
(3) For comparison with Society requirements for material, NDT and pressure testing as applicable.
(4) All engines.
(5) Only for engines of a cylinder diameter of 200 mm or more or a crankcase volume of 0.6 m^3 or more.
(6) The documentation to contain specifications for pressures, pipe dimensions and materials.
(7) The type test report may be submitted shortly after the conclusion of the type test.

Table 3 : Documentation for the inspection of components and systems

No.	Item
1	Engine particulars as per data sheet in App 9 App 12 of Tasneef Rules for the Classification of Ships
2	Material specifications of main parts with information on non-destructive material tests and pressure tests **(1)**
3	Bedplate and crankcase of welded design, with welding details and welding instructions **(2)**
4	Thrust bearing bedplate of welded design, with welding details and welding instructions **(2)**
5	Frame/framebox/gearbox of welded design, with welding details and instructions **(2)**
6	Crankshaft, assembly and details
7	Thrust shaft or intermediate shaft (if integral with engine)
8	Shaft coupling bolts
9	Bolts and studs for main bearings
10	Bolts and studs for cylinder heads and exhaust valve (two stroke design)
11	Bolts and studs for connecting rods
12	Tie rods
	Schematic layout or other equivalent documents on the engine of:
13	• Starting air system
14	• Fuel oil system
15	• Lubricating oil system
16	• Cooling water system
17	• Hydraulic system
18	• Hydraulic system (for valve lift)
19	• Engine control and safety system
20	Shielding of high pressure fuel pipes, assembly **(4)**
21	Construction of accumulators for hydraulic oil and fuel oil
22	High pressure parts for fuel oil injection system **(5)**
23	Arrangement and details of the crankcase explosion relief valve (see [2.3]) **(6)**
24	Oil mist detection and/or alternative alarm arrangements (see [2.3])
25	Cylinder head
26	Cylinder block, engine block
27	Cylinder liner

(1) For comparison with Society requirements for material, NDT and pressure testing as applicable.
(2) For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.
(3) Details of the system so far as supplied by the engine manufacturer such as: main dimensions, operating media and maximum working pressures.
(4) All engines.
(5) The documentation to contain specifications for pressures, pipe dimensions and materials.
(6) Only for engines of a cylinder diameter of 200 mm or more or a crankcase volume of 0.6 m^3 or more.
(7) Including identification (e.g. drawing number) of components.
(8) Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
(9) Required for engines that rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves.
(10) Documents modified for a specific application are to be submitted to the Classification Society for information or approval, as applicable. See [3.2], App 9 App 12 of Tasneef Rules for the Classification of Ships and App 10 App 12 of Tasneef Rules for the Classification of Ships.

No.	Item
28	Counterweights (if not integral with crankshaft), including fastening
29	Connecting rod with cap
30	Crosshead
31	Piston rod
32	Piston, assembly **(7)**
33	Piston head
34	Camshaft drive, assembly **(7)**
35	Flywheel
36	Arrangement of foundation (for main engines only)
37	Fuel oil injection pump
38	Shielding and insulation of exhaust pipes and other parts of high temperature which may be impinged as a result of a fuel system failure, assembly
39	Construction and arrangement of dampers
	For electronically controlled engines, assembly drawings or arrangements of:
40	• Control valves
41	• High-pressure pumps
42	• Drive for high pressure pumps
43	• Valve bodies, if applicable
44	Operation and service manuals **(8)**
45	Test program resulting from FMEA (for engine control system) **(9)**
46	Production specifications for castings and welding (sequence)
47	Type approval certification for environmental tests, control components **(10)**
48	Quality requirements for engine production

(1) For comparison with Society requirements for material, NDT and pressure testing as applicable.
(2) For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.
(3) Details of the system so far as supplied by the engine manufacturer such as: main dimensions, operating media and maximum working pressures.
(4) All engines.
(5) The documentation to contain specifications for pressures, pipe dimensions and materials.
(6) Only for engines of a cylinder diameter of 200 mm or more or a crankcase volume of 0.6 m^3 or more.
(7) Including identification (e.g. drawing number) of components.
(8) Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
(9) Required for engines that rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves.
(10) Documents modified for a specific application are to be submitted to the Classification Society for information or approval, as applicable. See [3.2], App 9 App 12 of Tasneef Rules for the Classification of Ships and App 10 App 12 of Tasneef Rules for the Classification of Ships.

4 Design and construction

4.1 Materials and welding

4.1.1 Crankshaft materials

In general, crankshafts are to be of forged steel having a tensile strength not less than 400 N/mm^2 and not greater than 1000 N/mm^2.

The use of forged steels of higher tensile strength is subject to special consideration by the Society in each case.

The Society, at its discretion and subject to special conditions (such as restrictions in navigation), may accept crankshafts made of cast carbon steel, cast alloyed steel or spheroidal or nodular graphite cast iron of appropriate quality and manufactured by a suitable procedure having a tensile strength as follows:

a) between 400 N/mm^2 and 560 N/mm^2 for cast carbon steel

b) between 400 N/mm^2 and 700 N/mm^2 for cast alloyed steel.

The acceptable values of tensile strength for spheroidal or nodular graphite cast iron will be considered by the Society on a case by case basis.

4.1.2 Welded frames and foundations

Steels used in the fabrication of welded frames and bedplates are to comply with the requirements of Part D.

Welding is to be in accordance with the requirements of Sec 1, [2.2].

4.2 Crankshaft

4.2.1 Check of the scantling

The check of crankshaft strength is to be carried out in accordance with App 1 of Tasneef Rules for the Classification of Ships.

4.3 Crankcase

4.3.1 Strength

Crankcase construction and crankcase doors are to be of sufficient strength to withstand anticipated crankcase pressures that may arise during a crankcase explosion taking into account the installation of explosion relief valves required in [4.3.4]. Crankcase doors are to be fastened sufficiently securely for them not be readily displaced by a crankcase explosion.

4.3.2 Ventilation and drainage

Ventilation of the crankcase, or any arrangement which could produce a flow of external air within the crankcase, is in principle not permitted except for dual fuel engines, where crankcase ventilation is to be provided in accordance with App 2, [2.1.1] of Tasneef Rules for the Classification of Ships.

Where provided, crankcase ventilation pipes are to be as small as practicable to minimise the inrush of air after a crankcase explosion.

If forced extraction of the oil mist atmosphere gases from the crankcase is provided (for mist smoke detection purposes, for instance), the vacuum in the crankcase is not to exceed $2,5 \times 10^{-4}$ N/mm^2.

To avoid interconnection between crankcases and the possible spread of fire following an explosion, crankcase ventilation pipes and oil drain pipes for each engine are to be independent of any other engine.

Lubricating oil drain pipes from the engine sump to the drain tank are to be submerged at their outlet ends.

4.3.3 Warning notice

A warning notice is to be fitted either on the control stand or, preferably, on a crankcase door on each side of the engine.

This warning notice is to specify that, whenever overheating is suspected within the crankcase, the crankcase doors or sight holes are not to be opened before a reasonable time has elapsed, sufficient to permit adequate cooling after stopping the engine.

4.3.4 Relief valves

a) Diesel engines of a cylinder diameter of 200 mm and above or a crankcase gross volume of 0,6 m^3 and above are to be provided with crankcase explosion relief valves according to the requirements of this item [4.3.4].

   The total volume of the stationary parts within the crankcase may be discounted in estimating the crankcase gross volume (rotating and reciprocating components are to be included in the gross volume).

b) Relief valves are to be provided with lightweight spring-loaded valve discs or other quick-acting and self-closing devices to relieve a crankcase of pressure in the event of an internal explosion and to prevent the inrush of air thereafter.

   The valve discs in relief valves are to be made of ductile material capable of withstanding the shock of contact with stoppers at the full open position.

   Relief valves are to be designed and constructed to open quickly and be fully open at a pressure not greater than 0,02 N/mm^2.

The free area of each crankcase explosion relief valve is not to be less than 45 cm^2. The aggregate free area of the valves fitted on an engine is not to be less than 115 cm^2 per cubic metre of the crankcase gross volume.

Relief valves are to be provided with a flame arrester that permits flow for crankcase pressure relief and prevents passage of flame following a crankcase explosion.

Relief valves are to be type approved. Type testing is to be carried out in a configuration that represents the installation arrangements that will be used on an engine in accordance with App 5 of Tasneef Rules for the Classification of Ships

Where relief valves are provided with arrangements for shielding emissions from the valve following an explosion, the valve is to be type tested to demonstrate that the shielding does not adversely affect the operational effectiveness of the valve.

c) Relief valves are to be provided with a copy of the Manufacturer's installation and maintenance manual that is pertinent to the size and type of valve being supplied for installation on a particular engine.

The manual is to contain the following information:

1) Description of valve with details of function and design limits
2) Copy of type test certification
3) Installation instructions
4) Maintenance in service instructions to include testing and renewal of any sealing arrangements
5) Actions required after a crankcase explosion.

A copy of the installation and maintenance manual required above is to be provided on board .

Plans showing details and arrangements of crankcase explosion relief valves are to be submitted for approval in accordance with Tab 1.

Valves are to be provided with suitable markings that include the following information:

- Name and address of Manufacturer
- Designation and size
- Month/Year of manufacture
- Approved installation orientation.

d) Engines of a cylinder diameter of 200 mm and above, but not exceeding 250 mm, are to have at least one valve near each end; however, for engines with more than 8 crankthrows, an additional valve is to be fitted near the middle of the engine.

Engines of a cylinder diameter of 250 mm and above, but not exceeding 300 mm, are to have at least one valve in way of each alternate crankthrow, with a minimum of two valves.

Engines of a cylinder diameter exceeding 300 mm are to have at least one valve in way of each main crankthrow.

e) Additional relief valves are to be fitted on separate spaces of the crankcase, such as gear or chain cases for camshaft or similar drives, when the gross volume of such spaces is 0,6 m^3 or above.

Scavenge spaces in open connection to the cylinders are to be fitted with explosion relief valves.

4.3.5 Oil mist detection/monitoring arrangements

Oil mist detection arrangements (or engine bearing temperature monitors or equivalent devices) are required:

- for alarm and slowdown purposes for low speed diesel engines of 2250 kW and above or having cylinders of more than 300 mm bore (see Note 1)
- for alarm and automatic shut-off purposes for medium and high speed diesel engines of 2250 kW and above or having cylinders of more than 300 mm bore (see Note 1).

Note 1:

Low-Speed Engines means diesel engines having a rated speed of less than 300 rpm.

Medium-Speed Engines means diesel engines having a rated speed of 300 rpm and above, but less than 1400 rpm.

High-Speed Engines means diesel engines having a rated speed of 1400 rpm and above.

Oil mist detection arrangements are to be of a type approved by the Society and tested in accordance with App 6 of Tasneef Rules for the Classification of Ships and are to comply with the requirements indicated hereinafter.

Engine bearing temperature monitors or equivalent devices used as safety devices are to be of a type approved by classification societies for such purposes.

Equivalent devices mean measures applied to high speed engines where specific design features are incorporated to preclude the risk of crankcase explosions.

The oil mist detection system and arrangements are to be installed in accordance with the engine Designer's and oil mist Manufacturer's instructions/recommendations. The following particulars are to be included in the instructions:

- Schematic layout of engine oil mist detection and alarm system showing location of engine crankcase sample points and piping or cable arrangements together with pipe dimensions to detector
- Evidence of study to justify the selected location of sample points and sample extraction rate (if applicable) in consideration of the crankcase arrangements and geometry and the predicted crankcase atmosphere where oil mist can accumulate
- The Manufacturer's maintenance and test manual
- Information relating to type or in-service testing of the engine carried out with engine protection system test arrangements having approved types of oil mist detection equipment.

A copy of the oil mist detection equipment maintenance and test manual required above is to be provided on board .

Oil mist detection and alarm information is to be capable of being read from a safe location away from the engine.

Each engine is to be provided with its own independent oil mist detection arrangement and a dedicated alarm.

Oil mist detection and alarm systems are to be capable of being tested on the test bed and on board under engine at standstill and engine running at normal operating conditions in accordance with test procedures that are acceptable to the Society.

Alarms and shutdowns for the oil mist detection/monitoring system are to be in accordance with Pt F, Ch 2, Sec 1, Tab 2, Pt F, Ch 2, Sec 1, Tab 3 and Pt F, Ch 2, Sec 1, Tab 24 and the system arrangements are to comply with Ch 3, Sec 2, [6] and Ch 3, Sec 2, [7].

The oil mist detection arrangements are to provide an alarm indication in the event of a foreseeable functional failure in the equipment and installation arrangements.

The oil mist detection system is to provide an indication that any lenses fitted in the equipment and used in determination of the oil mist level have been partially obscured to a degree that will affect the reliability of the information and alarm indication.

Where oil mist detection equipment includes the use of programmable electronic systems, the arrangements are to be in accordance with Chapter 3.

Plans showing details and arrangements of oil mist detection arrangements are to be submitted for approval in accordance with Tab 1.

The equipment together with detectors is to be tested when installed on the test bed and on board to demonstrate that the detection and alarm system functionally operates. The testing arrangements are to be to the satisfaction of the Society.

Where sequential oil mist detection arrangements are provided, the sampling frequency and time are to be as short as reasonably practicable.

Where alternative methods are provided for the prevention of the build-up of potentially explosive oil mist conditions within the crankcase, details are to be submitted for consideration. The following information is to be included in the details to be submitted for consideration:

- Engine particulars - type, power, speed, stroke, bore and crankcase volume
- Details of arrangements to prevent the build-up of potentially explosive conditions within the crankcase, e.g. bearing temperature monitoring, oil splash temperature, crankcase pressure monitoring, recirculation arrangements
- Evidence to demonstrate that the arrangements are effective in preventing the build-up of potentially explosive conditions together with details of in-service experience
- Operating instructions and the maintenance and test instructions.

Where it is proposed to use the introduction of inert gas into the crankcase to minimise a potential crankcase explosion, details of the arrangements are to be submitted to the Society for consideration.

4.4 Scavenge manifolds

4.4.1 Fire extinguishing

For two-stroke crosshead type engines, scavenge spaces in open connection (without valves) to the cylinders are to be connected to a fixed fire-extinguishing system, which is to be entirely independent of the fire-extinguishing system of the machinery space.

4.4.2 Blowers

Where a single two-stroke propulsion engine is equipped with an independently driven blower, alternative means to drive the blower or an auxiliary blower are to be provided ready for use.

4.4.3 Relief valves

Scavenge spaces in open connection to the cylinders are to be fitted with explosion relief valves in accordance with [4.3.4].

4.5 Systems

4.5.1 General

In addition to the requirements of the present sub-article, those given in Sec 10 are to be satisfied.

Flexible hoses in the fuel and lubricating oil system are to be limited to the minimum and are to be type approved.

Unless otherwise stated in Sec 10, propulsion engines are to be equipped with external connections for standby pumps for:

- fuel oil supply
- lubricating oil and cooling water circulation.

4.5.2 Fuel oil system

Relief valves discharging back to the suction of the pumps or other equivalent means are to be fitted on the delivery side of the pumps.

In fuel oil systems for propulsion machinery, filters are to be fitted and arranged so that an uninterrupted supply of filtered fuel oil is ensured during cleaning operations of the filter equipment, except when otherwise stated in Sec 10.

a) *All external high pressure fuel delivery lines between the high pressure fuel pumps and fuel injectors are to be protected with a shielded piping system capable of containing fuel from a high pressure line failure.*

   A shielded pipe incorporates an outer pipe into which the high pressure fuel pipe is placed forming a permanent assembly.

   The shielded piping system is to include a means for collection of leakages and arrangements are to be provided for an alarm to be given in the event of a fuel line failure.

   If flexible hoses are used for shielding purposes, these are to be approved by the Society.

   When in fuel oil return piping the pulsation of pressure with peak to peak values exceeds 2 MPa, shielding of this piping is also required as above.

b) For yachts with short range navigation, the requirements under a) may be relaxed at the Society’s discretion.

4.5.3 Lubricating oil system

Efficient filters are to be fitted in the lubricating oil system when the oil is circulated under pressure.

In such lubricating oil systems for propulsion machinery, filters are to be arranged so that an uninterrupted supply of filtered lubricating oil is ensured during cleaning operations of the filter equipment, except when otherwise stated in Sec 10.

Relief valves discharging back to the suction of the pumps or other equivalent means are to be fitted on the delivery side of the pumps.

The relief valves may be omitted provided that the filters can withstand the maximum pressure that the pump may develop.

Where necessary, the lubricating oil is to be cooled by means of suitable coolers.

4.5.4 Charge air system

a) Requirements relevant to design, construction, arrangement, installation, tests and certification of exhaust gas turbochargers are given in Sec 14.

b) When two-stroke propulsion engines are supercharged by exhaust gas turbochargers which operate on the impulse system, provision is to be made to prevent broken piston rings entering turbocharger casings and causing damage to blades and nozzle rings.

4.6 Starting air system

4.6.1

The requirements given in [5.1] apply.

4.7 Control and monitoring

4.7.1 General

In addition to those of this item [4.7], the general requirements given in Chapter 3 apply.

In the case of yachts with automation notations, the requirements in Part F, Chapter 2 also apply.

4.7.2 Alarm

The lubricating oil system of diesel engines with a power equal to or in excess of 37 kW is to be fitted with alarms to give audible and visual warning in the event of an appreciable reduction in pressure of the lubricating oil supply.

4.7.3 Governors of main and auxiliary engines

Each engine, except the auxiliary engines for driving electric generators for which [4.7.5] applies, is to be fitted with a speed governor so adjusted that the engine does not exceed the rated speed by more than 15%.

4.7.4 Overspeed protective devices of main and auxiliary engines

In addition to the speed governor, each

- main propulsion engine having a rated power of 220kW and above, which can be declutched or which drives a controllable pitch propeller, and
- auxiliary engine having a rated power of 220kW and above, except those for driving electric generators, for which [4.7.6] applies

is to be fitted with a separate overspeed protective device so adjusted that the engine cannot exceed the rated speed n by more than 20%; arrangements are to be made to test the overspeed protective device.

Equivalent arrangements may be accepted subject to special consideration by the Society in each case.

The overspeed protective device, including its driving mechanism or speed sensor, is to be independent of the governor.

4.7.5 Governors for auxiliary engines driving electric generators

a) Auxiliary engines intended for driving electric generators are to be fitted with a speed governor which prevents transient frequency variations in the electrical network in excess of ±10% of the rated frequency with a recovery time to steady state conditions not exceeding 5 seconds, when the maximum electrical step load is switched on or off.

   When a step load equivalent to the rated output of a generator is switched off, a transient speed variation in excess of 10% of the rated speed may be acceptable, provided this does not cause the intervention of the overspeed device as required by [4.7.4].

b) At all loads between no load and rated power, the permanent speed variation is not to be more than 5% of the rated speed.

c) Prime movers are to be selected in such a way that they meet the load demand within the yacht's mains and, when running at no load, can satisfy the requirement in item a) above if suddenly loaded to 50% of the rated power of the generator, followed by the remaining 50% after an interval sufficient to restore speed to steady state. Steady state conditions (see Note 1) are to be achieved in not more than 5 s.

Note 1: Steady state conditions are those at which the envelope of speed variation does not exceed ±1% of the declared speed at the new power.

d) Application of the electrical load in more than 2 load steps can only be allowed if the conditions within the yachts mains permit the use of those auxiliary engines which can only be loaded in more than 2 load steps (see Fig 1 on 4-stroke diesel engines expected maximum possible sudden power increase) and provided that this is already allowed for in the designing stage.

   This is to be verified in the form of system specifications to be approved and to be demonstrated at yacht's trials. In this case, due consideration is to be given to the power required for the electrical equipment to be automatically switched on after blackout and to the sequence in which it is connected.

   This also applies to generators to be operated in parallel and where the power is to be transferred from one generator to another, in the event that any one generator is to be switched off.

e) Emergency generator sets must satisfy the governor conditions as per items a) and b), even when:

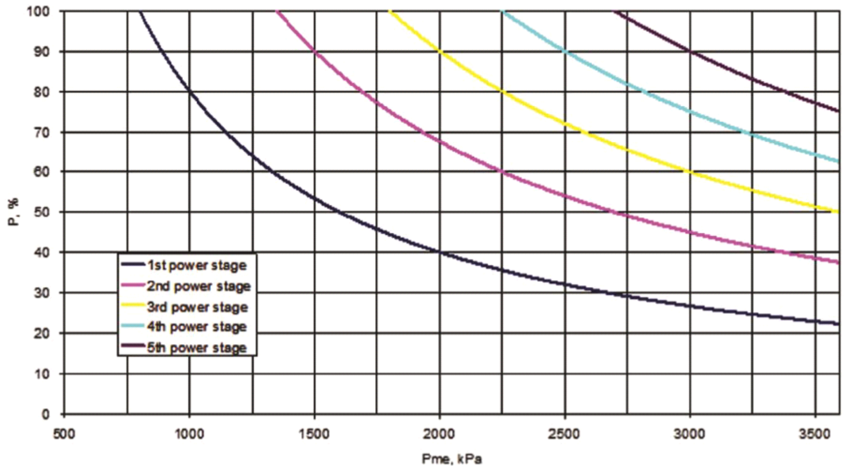
   1) their total consumer load is applied suddenly, or
   2) their total consumer load is applied in steps, provided that:
      - the total load is supplied within 45 seconds of power failure on the main switchboard, and
      - the maximum step load is declared and demonstrated, and
      - the power distribution system is designed such that the declared maximum step loading is not exceeded, and

- compliance of time delays and loading sequence with the above is demonstrated at yacht's trials.

f) For alternating current generating sets operating in parallel, the governing characteristics of the prime movers are to be such that, within the limits of 20% and 100% total load, the load on any generating set will not normally differ from its proportionate share of the total load by more than 15% of the rated power in kW of the largest machine or 25% of the rated power in kW of the individual machine in question, whichever is the lesser.

For alternating current generating sets intended to operate in parallel, facilities are to be provided to adjust the governor sufficiently finely to permit an adjustment of load not exceeding 5% of the rated load at normal frequency.

Figure 1 : Reference values for maximum possible sudden power increases as a function of brake mean effective pressure, Pme, at declared power (four-stroke diesel engines)



Pme: declared power mean effective pressure

P : power increase referred to declared power at site conditions

1 : first power stage - 2 : second power stage - 3 : third power stage - 4 : fourth power stage - 5 : fifth power stage

4.7.6 Overspeed protective devices of auxiliary engines driving electric generators

In addition to the speed governor, auxiliary engines of rated power equal to or greater than 220 kW driving electric generators are to be fitted with a separate overspeed protective device, with a means for manual tripping, adjusted so as to prevent the rated speed from being exceeded by more than 15%.

This device is to automatically shut down the engine.

4.7.7 Use of electronic governors

a) Type approval

Electronic governors and their actuators are to be type approved by the Society, according to Ch 3, Sec 6.

b) Electronic governors for main propulsion engines

If an electronic governor is fitted to ensure continuous speed control or resumption of control after a fault, an additional separate governor is to be provided unless the engine has a manually operated fuel admission control system suitable for its control.

A fault in the governor system is not to lead to sudden major changes in propulsion power or direction of propeller rotation.

Alarms are to be fitted to indicate faults in the governor system.

The acceptance of electronic governors not in compliance with the above requirements will be considered by the Society on a case by case basis, when fitted on yachts with two or more main propulsion engines.

c) Electronic governors for auxiliary engines driving electric generators

In the event of a fault in the electronic governor system the fuel admission is to be set to “zero”.

Alarms are to be fitted to indicate faults in the governor system.

d) The acceptance of electronic governors fitted on engines driving emergency generators will be considered by the Society on a case by case basis, anyway, a back-up pre-programmed governor is to be provided for immediate replacement in case of failure of the governor in use; if practicable, the backup governor is to be in place, fixed to the engine in a position near to the governor in use, and arranged so that the exchange is quick, easy and error-free; special consideration is to be given to the governor power supply.

4.7.8 Alarms and safeguards for emergency reciprocating I.C. engines

a) These requirements apply to reciprocating I.C. engines, which use distillate marine fuels covered by ISO 8217:2017, required to be immediately available in an emergency (i.e. emergency generating set engine, emergency fire pump engine, etc.) and capable of being controlled remotely or automatically operated.

b) Information demonstrating compliance with these requirements is to be submitted to the Society. The information is to include instructions to test the alarm and safety systems.

c) The alarms and safeguards are to be fitted in accordance with Tab 6. It is the responsibility of the Manufacturer to set the alarms and safeguards so that they activate when the controlled parameter deviates from normal values but before reaching hazardous conditions.

d) The safety and alarm systems are to be designed to 'fail safe'. The characteristics of the 'fail safe' operation are to be evaluated on the basis not only of the system and its associated machinery, but also the complete installation, as well as the yacht.

e) Regardless of the engine output, if shutdowns additional to those specified in Tab 6, except for the overspeed shutdown, are provided, they are to be automatically overridden when the engine is in automatic or remote control mode during navigation.

f) The alarm system is to function in accordance with Part F, Chapter 2 with the additional requirement that grouped alarms are to be arranged on the bridge.

g) In addition to the fuel oil control from outside the space, a local means of engine shutdown is to be provided.

h) Local indications of at least those parameters listed in are Tab 6 to be provided within the same space as the reciprocating I.C engines and are to remain operational in the event of failure of the alarm and safety systems.

4.7.9 Summary tables

Diesel engines are to be equipped with monitoring equipment as detailed in Tab 4 and Tab 5, for main propulsion and auxiliary services, respectively.

For yachts with short range navigation, the acceptance of a reduction in the monitoring equipment required in Tab 4 and Tab 5 may be considered.

The alarms are to be visual and audible.

The indicators are to be fitted at a normally attended position (on the engine or at the local control station).

It is the responsibility of the Manufacturer to set the alarms and safeguards so that they activate when the controlled parameter deviates from normal values but before reaching hazardous conditions.

In the case of diesel engines required to be immediately available in an emergency and capable of being controlled remotely or automatically operated, Tab 6 applies.

Table 4 : Monitoring of main propulsion diesel engines *(1/1/2025)*

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Main Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Fuel oil pressure after filter (engine inlet)		local					
Leakage from high pressure pipes where required	H						
Lubricating oil to main bearing and thrust bearing pressure **(5)**	L	local					
	LL			X			
Lubricating oil to cross-head bearing pressure when separate **(5)**	L	local					
	LL			X			

(1) Not required, if the coolant is oil taken from the main cooling system of the engine
(2) Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted
(3) For engines of 220 kW and above
(4) Indication is required after each cylinder, for engines of 500 kW/cylinder and above
(5) To ensure independency of safety functions from control and monitoring functions, a separate sensor is to be installed for each row of the table.

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Main Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Lubricating oil to camshaft pressure when separate **(5)**	L	local					
	LL			X			
Turbocharger lubricating oil inlet pressure		local					
Lubricating oil inlet temperature		local					
Thrust bearing pads or bearing outlet temperature	H	local					
Cylinder fresh cooling water system inlet pressure	L	local **(3)**					
Cylinder fresh cooling water outlet temperature or, when common cooling space without individual stop valves, the common cylinder water outlet temperature		local					
Piston coolant inlet pressure on each cylinder **(1)**	L	local					
Piston coolant outlet temperature on each cylinder **(1)**		local					
Piston coolant outlet flow on each cylinder **(1) (2)**	L						
Scavenging air receiver pressure		local					
Scavenging air box temperature (Detection of fire in receiver)		local					
Exhaust gas temperature		local **(4)**					
Engine speed / direction of speed (when reversible) **(5)**		local					
	H			X			
Fault in the electronic governor system	X						

(1) Not required, if the coolant is oil taken from the main cooling system of the engine
(2) Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted
(3) For engines of 220 kW and above
(4) Indication is required after each cylinder, for engines of 500 kW/cylinder and above
(5) To ensure independency of safety functions from control and monitoring functions, a separate sensor is to be installed for each row of the table.

Table 5 : Monitoring of diesel engines used for auxiliary services *(1/1/2025)*

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Fuel oil viscosity or temperature before injection		local					
Fuel oil leakage from pressure pipes	H						
Lubricating oil pressure	L	local		X **(1)**			

(1) Not acceptable to emergency generator set
(2) Only requested for diesel engines having rating of 220 kW and above
(3) To ensure independency of safety functions from control and monitoring functions, a separate sensor is to be installed for each row of the table.

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Pressure or flow of cooling water, if not connected to main system	L	local					
Temperature of cooling water or cooling air		local					
Engine speed **(3)**		local					
	H			X **(2)**			
Fault in the electronic governor system	X						

(1) Not acceptable to emergency generator set
(2) Only requested for diesel engines having rating of 220 kW and above
(3) To ensure independency of safety functions from control and monitoring functions, a separate sensor is to be installed for each row of the table.

Table 6 : Monitoring of reciprocating I.C. engines required to be immediately available in an emergency and capable of being controlled remotely or automatically operated

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Engine			Auxiliary	
Identification of system parameter	Alarm activation	Indication	Slow-down	Shut-down with alarm	Control	Stand by Start	Stop
Fuel oil leakage from high pressure pipes (fuel injection pipes and common rails)	X						
Lubricating oil pressure	L	local					
Lubricating oil temperature **(1)**	H	local					
Pressure or flow of cooling water **(1)**	L	local					
Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: • the engine main and crank bearing oil outlet; or • the engine main and crank bearing) **(2)**	X	local					
Temperature of cooling water or cooling air	H	local					
Engine Overspeed activated **(1)**, **(3)**		local					
				X			
Fault in the electronic governor system	X						

(1) Requested only for engines having a power of or more than 220 kW .
(2) Requested only for engines having a power of or more than 2250 kW or cylinder bore of 300 mm and above
(3) To ensure independency of safety functions from control and monitoring functions, a separate sensor is to be installed for each row of the table.

5 Arrangement and installation

5.1 Starting arrangements

5.1.1 Mechanical air starting

a) Air starting the main and auxiliary engines is to be arranged such that the necessary air for the first charge can be produced on board the yacht without external aid.

b) The total capacity of air receivers is to be sufficient to provide, without replenishment, not less than 12 consecutive starts alternating between ahead and astern of each main engine of the reversible type, and not less than 6 consecutive starts of each main non-reversible type engine connected to a controllable pitch propeller or other device enabling the start without opposite torque.

   When other users such as auxiliary engine starting systems, control systems, whistle etc. are connected to the starting air receivers of main propulsion engines, their air consumption is also to be taken into account.

   Regardless of the above, for multi-engine installations the total number of starts required to be provided from the starting air receivers is indicated in Tab 7, valid when all the air receivers may be used to start all propulsion engines; if each engine or group of engines connected to a shaft is fitted with dedicated air receivers, the minimum number of starts for each group of engines connected to the same shaft is 12 for reversible engines and 6 for non-reversible engines.

   In case of Diesel-electric or turbine-electric propulsion, the minimum number of total consecutive starts required to be provided from the starting air receivers is to be determined from the following equation:

   $S = 6 + N (N - 1)$

   where

   S : total number of consecutive starts

   N : number of engines. (need not to be greater than 3).

c) If other compressed air systems, such as control air, are supplied from the same starting air receivers, the total capacity of the receivers is to be sufficient for continued operation of these systems after the air necessary for the required number of starts has been used.

d) The main starting air arrangements for main propulsion or auxiliary diesel engines are to be adequately protected against the effects of backfiring and internal explosion in the starting air pipes. To this end, the following safety devices are to be fitted:

   - An isolating non-return valve, or equivalent, at the starting air supply connection to each engine.
   - A bursting disc or flame arrester:
     - in way of the starting valve of each cylinder, for direct reversing engines having a main starting air manifold
     - at least at the supply inlet to the starting air manifold, for non-reversing engines.

     The bursting disc or flame arrester above may be omitted for engines having a bore not exceeding 230 mm.

   Other protective devices will be specially considered by the Society.

   The requirements of this item d) do not apply to engines started by pneumatic motors.

e) Compressed air receivers are to comply with the requirements of Sec 5. Compressed air piping and associated air compressors are to comply with the requirements of Sec 10.

5.1.2 Electrical starting

a) Where main internal combustion engines are arranged for electrical starting, at least two separate batteries are to be fitted.

   The arrangement is to be such that the batteries cannot be connected in parallel.

   Each battery is to be capable of starting the main engine when in cold and ready to start condition.

   The combined capacity of batteries is to be sufficient to provide within 30 min, without recharging, the number of starts required in [5.1.1] (b) in the event of air starting.

b) Electrical starting arrangements for auxiliary engines are to have two separate storage batteries or may be supplied by two separate circuits from main engine storage batteries when these are provided. In the case of a single auxiliary engine, one battery is acceptable. The combined capacity of the batteries is to be sufficient for at least three starts for each engine.

c) The starting batteries are only to be used for starting and for the engine's alarm and monitoring. Provision is to be made to maintain the stored energy at all times.

d) Each charging device is to have at least sufficient rating for recharging the required capacity of batteries within 6 hours.

Table 7 : Required number of starts

	Single propeller vessels		Multiple propeller vessels	
Engine type	One engine per shaft	Two or more engines per shaft	One engine per shaft	Two or more engines per shaft
Reversible	12	16	24	24
Non-reversible	6	8	8	8

5.1.3 Special requirements for 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 shall 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 shall 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 shall 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 shall 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:
- electrical and hydraulic starting systems shall be maintained from the emergency switchboard
- 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
- 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, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or powder charge cartridges, is permissible where this can be demonstrated as being effective.

e) When manual starting is not practicable, the requirements of (b) and (c) are to be complied with, except that starting may be manually initiated.

5.2 Turning gear

5.2.1

Each engine is to be provided with hand-operated turning gear; where deemed necessary, the turning gear is to be both hand and mechanically-operated.

The turning gear engagement is to inhibit starting operations.

5.3 Trays

5.3.1

Trays fitted with means of drainage are to be provided in way of the lower part of the crankcase and, in general, in way of the parts of the engine, where oil is likely to spill in order to collect the fuel oil or lubricating oil dripping from the engine.

5.4 Exhaust gas system

5.4.1

In addition to the requirements given in Sec 10, the exhaust system is to be efficiently cooled or insulated in such a way that the surface temperature does not exceed 220°C (see also Sec 1, [3.7]).

6 Type tests

6.1 Type tests - General

6.1.1 *(1/1/2025)*

Type testing is required for every new engine type intended for installation onboard yachts subject to classification in accordance with Pt A, Ch 2, App 3.

6.1.2 *(1/1/2025)*

For light duty and medium duty engines [6.12] applies.

6.2 Objectives

6.2.1

The type testing, is to be arranged to represent typical foreseen service load profiles, as specified by the engine builder, as well as to cover for required margins due to fatigue scatter and reasonably foreseen in-service deterioration.

This applies to:

- Parts subjected to high cycle fatigue (HCF) such as connecting rods, cams, rollers and spring tuned dampers where higher stresses may be provided by means of elevated injection pressure, cylinder maximum pressure, etc.
- Parts subjected to low cycle fatigue (LCF) such as "hot" parts when load profiles such as idle-full load -idle (with steep ramps) are frequently used.
- Operation of the engine at limits as defined by its specified alarm system, such as running at maximum permissible power with the lowest permissible oil pressure and/or highest permissible oil inlet temperature.

6.3 Validity

6.3.1

A type test carried out for a particular type of engine at any place of manufacture will be accepted for all engines of the same type built by licensees or the licensor, subject to each place of manufacture being found to be acceptable to the Society.

6.3.2

One type test will be considered adequate to cover a range of different numbers of cylinders. However, a type test of an in-line engine may not always cover the V-version. Subject to the individual Societies' discretion, separate type tests may be required for the V-version. On the other hand, a type test of a V-engine covers the in-line engines, unless the bmep is higher.

Items such as axial crankshaft vibration, torsional vibration in camshaft drives, and crankshafts, etc. may vary considerably with the number of cylinders and may influence the choice of engine to be selected for type testing.

6.3.3

The engine is type approved up to the tested ratings and pressures (100% corresponding to MCR).

Provided documentary evidence of successful service experience with the classified rating of 100% is submitted, an increase (if design approved*) may be permitted without a new type test if the increase from the type tested engine is within:

- 5% of the maximum combustion pressure, or
- 5% of the mean effective pressure, or
- 5% of the rpm

*Only crankshaft calculation and crankshaft drawings, if modified.

Providing maximum power is not increased by more than 10%, an increase of maximum approved power may be permitted without a new type test provided engineering analysis and evidence of successful service experience in similar field applications (even if the application is not classified) or documentation of internal testing are submitted if the increase from the type tested engine is within:

- 10% of the maximum combustion pressure, or
- 10% of the mean effective pressure, or
- 10% of the rpm.

6.4 De-rated engine

6.4.1

If an engine has been design approved, and internal testing per Stage A is documented to a rating higher than the one type tested, the Type Approval may be extended to the increased power/mep/rpm upon submission of an Extended Delivery Test Report at:

- Test at over speed (only if nominal speed has increased)
- Rated power, i.e. 100% output at 100% torque and 100% speed corresponding to load point No.1. (2 measurements with one running hour in between)
- Maximum permissible torque (normally 110%) at 100% speed corresponding to load point No.3 or maximum permissible power (normally 110%) and speed according to nominal propeller curve corresponding to load point 3a., for 30 minutes
- 100% power at maximum permissible speed corresponding to load point 2, for 30 minutes.

6.5 Integration Test

6.5.1

An integration test demonstrating that the response of the complete mechanical, hydraulic and electronic system is as predicted maybe carried out for acceptance of sub-systems (Turbo Charger, Engine Control System, Dual Fuel, Exhaust Gas treatment…) separately approved. The scope of these tests shall be proposed by the designer/licensor taking into account of impact on engine.

6.6 Safety precautions

6.6.1

Before any test run is carried out, all relevant equipment for the safety of attending personnel is to be made available by the manufacturer/shipyard and is to be operational, and its correct functioning is to be verified.

6.6.2

This applies especially to crankcase explosive conditions protection, but also over-speed protection and any other shut down function.

6.6.3

The inspection for jacketing of high-pressure fuel oil lines and proper screening of pipe connections (as required in [6.10.9] fire measures) is also to be carried out before the test runs.

6.6.4

Interlock test of turning gear is to be performed when installed.

6.7 Test programme

6.7.1 The type testing is divided into 3 stages:

- STAGE A - internal tests

  This includes some of the testing made during the engine development, function testing, and collection of measured parameters and records of testing hours. The results of testing required by the Society or stipulated by the designer are to be presented to the Society before starting stage B.
- STAGE B - witnessed tests

  This is the testing made in the presence of Classification Society personnel.
- STAGE C - component inspection

  This is the inspection of engine parts to the extent as required by the Society.

6.7.2

The complete type testing program is subject to approval by the Society. The extent of the Surveyor's attendance is to be agreed in each case, but at least during stage B and C.

6.7.3

Testing prior to the witnessed type testing (stage B and C), is also considered as a part of the complete type testing program.

6.7.4

Upon completion of complete type testing (stage A through C), a type test report is to be submitted to the Society for review. The type test report is to contain:

- overall description of tests performed during stage A. Records are to be kept by the builders QA management for presentation to the Classification Society.
- detailed description of the load and functional tests conducted during stage B.
- inspection results from stage C.

6.7.5

As required in [6.2] the type testing is to substantiate the capability of the design and its suitability for the intended operation. Special testing such as LCF and endurance testing will normally be conducted during stage A.

6.7.6

High speed engines for marine use are normally to be subjected to an endurance test of 100 hours at full load. Omission or simplification of the type test may be considered for the type approval of engines with long service experience from non-marine fields or for the extension of type approval of engines of a well-known type, in excess of the limits given in [6.3].

Propulsion engines for high speed vessels that may be used for frequent load changes from idle to full are normally to be tested with at least 500 cycles (idle - full load - idle) using the steepest load ramp that the control system (or operation manual if not automatically controlled) permits. The duration at each end is to be sufficient for reaching stable temperatures of the hot parts.

6.8 Measurements and recordings

6.8.1

During all testing the ambient conditions (air temperature, air pressure and humidity) are to be recorded.

6.8.2

As a minimum, the following engine data are to be measured and recorded.

- Engine r.p.m.
- Torque
- Maximum combustion pressure for each cylinder 1)
- Mean indicated pressure for each cylinder
- Charging air pressure and temperature
- Exhaust gas temperature
- Fuel rack position or similar parameter related to engine load
- Turbocharger speed
- All engine parameters that are required for control and monitoring for the intended use (propulsion, auxiliary, emergency).

Note 1: For engines where the standard production cylinder heads are not designed for such measurments, a special cylinder head made for this purpose may be used. In such a case, the measurements may be carried out as part of Stage A and are to be properly documented. Where deemed necessary e.g. for dual fuel engines, the measurement of maximum combustion pressure and mean indicated pressure may be carried out by indirect means, provided the re-liability of the method is documented.

Calibration records for the instrumentation used to collect data as listed above are to be presented to - and reviewed by the attending Surveyor.

Additional measurements may be required in connection with the design assessment.

6.9 Stage A - Internal tests

6.9.1

During the internal tests, the engine is to be operated at the load points important for the engine designer and the pertaining operating values are to be recorded. The load conditions to be tested are also to include the testing specified in the applicable type approval programme.

6.9.2

At least the following conditions are to be tested:

- Normal case:

The load points 25%, 50%, 75%, 100% and 110% of the maximum rated power for continuous operation, to be made along the normal (theoretical) propeller curve and at constant speed for propulsion engines (if applicable mode of operation i.e. driving controllable pitch propellers), and at constant speed for engines intended for generator sets including a test at no load and rated speed.

- The limit points of the permissible operating range. These limit points are to be defined by the engine manufacturer.
- For high speed engines, the 100 hr full load test and the low cycle fatigue test apply as required in connection with the design assessment.
- Specific tests of parts of the engine, required by the Society or stipulated by the designer.

6.10 Stage B - Witnessed tests

6.10.1

The tests listed below are to be carried out in the presence of a Surveyor. The achieved results are to be recorded and signed by the attending Surveyor after the type test is completed.

6.10.2

The over-speed test is to be carried out and is to demonstrate that the engine is not damaged by an actual engine overspeed within the overspeed shutdown system set-point. This test may be carried out at the manufacturer's choice either with or with-out load during the speed overshoot.

6.10.3 Load ponts

The engine is to be operated according to the power and speed diagram in Fig 2. The data to be measured and recorded when testing the engine at the various load points have to include all engine parameters listed in [6.8]. The operating time per load point depends on the engine size (achievement of steady state condition) and on the time for collection of the operating values. Normally, an operating time of 0.5 hour can be assumed per load point, however sufficient time should be allowed for visual inspection by the Surveyor.

6.10.4

The load points are:

- Rated power (MCR), i.e. 100% output at 100% torque and 100% speed corresponding to load point 1, normally for 2 hours with data collection with an interval of 1 hour. If operation of the engine at limits as defined by its specified alarm system (e.g. at alarm levels of lub oil pressure and inlet temperature) is required, the test should be made here.
- 100% power at maximum permissible speed corresponding to load point 2.
- Maximum permissible torque (at least and normally 110%) at 100% speed corresponding to load at point 3, or maximum permissible power (at least and normally 110%) and 103.2% speed according to the nominal propeller curve corresponding to load point 3a. Load point 3a applies to engines only driving fixed pitch propellers or water jets. Load point 3 applies to all other purposes.

Load point 3 (or 3a as applicable) is to be replaced with a load that corresponds to the specified overload and duration approved for intermittent use. This applies where such overload rating exceeds 110% of MCR. Where the approved intermittent overload rating is less than 110% of MCR, subject overload rating has to replace the load point at 100% of MCR. In such case the load point at 110% of MCR remains.

- Minimum permissible speed at 100% torque, corresponding to load point 4.
- Minimum permissible speed at 90% torque corresponding to load point 5. (Applicable to propulsion engines only).
- Part loads e.g. 75%, 50% and 25% of rated power and speed according to nominal propeller curve (i.e. 90.8%, 79.3% and 62.9% speed) corresponding to points 6, 7 and 8 or at constant rated speed setting corresponding to points 9, 10 and 11, depending on the intended application of the engine.
- Crosshead engines not restricted for use with C.P. propellers are to be tested with no load at the associated maximum permissible engine speed.

6.10.5

During all these load points, engine parameters are to be within the specified and approved values.

6.10.6 Operation with damaged turbocharger

For 2-stroke propulsion engines, the achievable continuous output is to be determined in the case of turbocharger damage.

Engines intended for single propulsion with a fixed pitch propeller are to be able to run continuously at a speed (r.p.m.) of 40% of full speed along the theoretical propeller curve when one turbocharger is out of operation. (The test can be performed by either by-passing the turbocharger, fixing the turbocharger rotor shaft or removing the rotor.).

6.10.7 Functional tests

- Verification of the lowest specified propulsion engine speed according to the nominal propeller curve as specified by the engine designer (even though it works on a water- brake). During this operation, no alarm shall occur.
- Starting tests, for non-reversible engines and/or starting and reversing tests, for reversible engines, for the purpose of determining the minimum air pressure and the consumption for a start.
- Governor tests: tests for compliance with [4.7.3] and [4.7.5] are to be carried out.

6.10.8 Integration test

For electronically controlled diesel engines, integration tests are to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes. The scope of these tests is to be agreed with the Society for selected cases based on the FMEA required in Tab 1.

6.10.9 Fire protection measures

Verification of compliance with requirements for jacketing of high-pressure fuel oil lines, screening of pipe connections in piping containing flammable liquids and insulation of hot surfaces:

- The engine is to be inspected for jacketing of high-pressure fuel oil lines, including the system for the detection of leakage, and proper screening of pipe connections in piping containing flammable liquids.
- Proper insulation of hot surfaces is to be verified while running the engine at 100% load, alternatively at the overload approved for intermittent use. Readings of surface temperatures are to be done by use of Infrared Thermoscanning Equipment. Equivalent measurement equipment may be used when so approved by the Society. Readings obtained are to be randomly verified by use of contact thermometers.

6.11 Stage C - Opening up for inspections

6.11.1

The crankshaft deflections are to be measured in the specified (by designer) condition (except for engines where no specification exists).

6.11.2

High speed engines for marine use are normally to be stripped down for a complete inspection after the type test.

6.11.3

For all the other engines, after the test run the components of one cylinder for in-line engines and two cylinders for V-engines are to be presented for inspection as follows (engines with long service experience from non-marine fields can have a reduced ex-tent of opening):

- piston removed and dismantled
- crosshead bearing dismantled
- guide planes
- connecting rod bearings (big and small end) dismantled (special attention to serrations and fretting on contact surfaces with the bearing backsides)
- main bearing dismantled
- cylinder liner in the installed condition
- cylinder head, valves disassembled
- cam drive gear or chain, camshaft and crankcase with opened covers. (The engine must be turnable by turning gear for this inspection.).

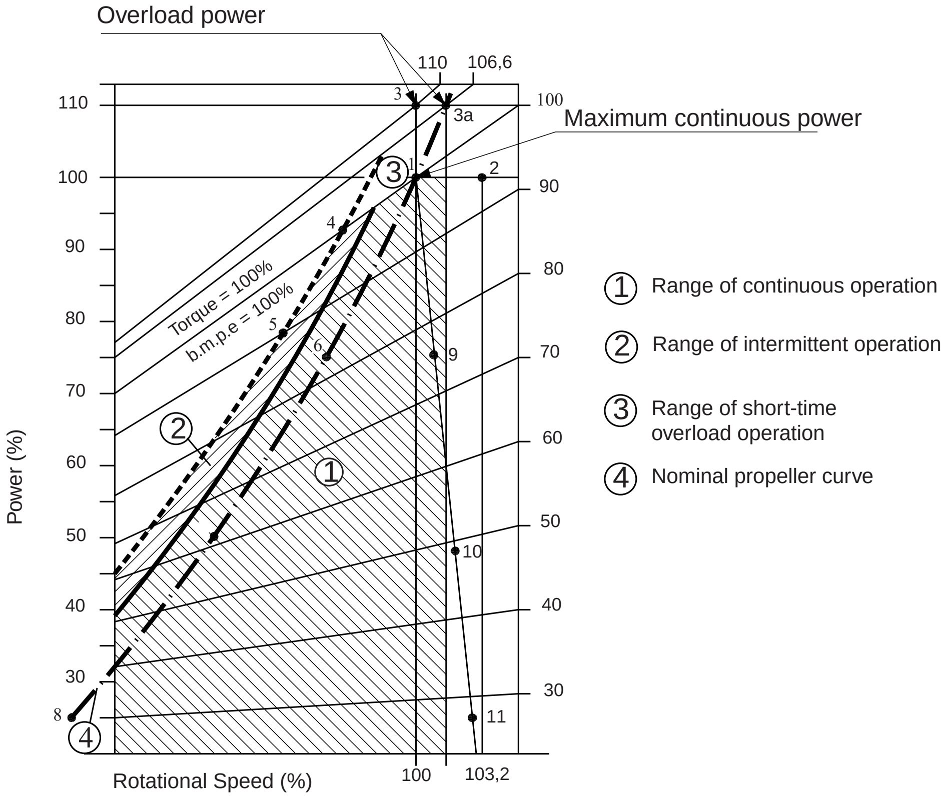
6.11.4

For V-engines, the cylinder units are to be selected from both cylinder banks and different crank throws.

6.11.5

If deemed necessary by the surveyor, further dismantling of the engine may be required.

Figure 2 : Power/speed diagram



6.12 Validity

6.12.1 Type test light duty and medium duty engines *(1/1/2025)*

The Manufacturer demanding the approval of light duty or medium duty engines operating profile is requested to declare contextually with the demand the following parameters:

- P_{MAX} = Maximum pressure in kW
- n_{MAX} = round per minute at power P_{MAX}
- TBO = time between two main overhaul, in number of running hours
- $O_{A\ MAX}$ = Motion hours per year
- $O_{P\ MAX}$ = Motion hours per year at P_{MAX}
- Ic Loading index where = $(P_{MEDIA^*} O_{A\ MAX})/(P_{MAX^*} O_{A\ MIN})$

Where P_{MAX} average power deliverable from the engine in $O_{A\ MAX}$ running hours per year.

For proceeding in the type approval, the parameters above declared by the Manufacturer are not to be less than the minimum ones provided for the operating profile in [1.6.2].

Engines with Light duty and Medium duty operative profiles are to be type tested in accordance with [6.12.2]. In this respect, Manufacturer is to be admitted to testing and inspections according to an alternative inspection scheme..

6.12.2 Type test *(1/1/2025)*

The programme of the type test is to be in general as specified below, P_{MAX} being the maximum power and n_{MAX} the corresponding speed. The maximum power is that stated by the engine Manufacturer and accepted by the Society, as defined in [1.6.1]:

- 80 hours at P_{MAX} e n_{MAX}
- 10 hours at partial loads (25%, 50%, 75% and 90% of power P_{MAX})
- 2 hours at intermittent loads
- starting tests
- testing of speed governor, overspeed device and lubricating oil system failure alarm device;
- testing of the engine with one turbocharger out of action, when applicable

- testing of the minimum speed along the nominal (theoretical) propeller curve, for main propulsion engines driving fixed pitch propellers, and of the minimum speed with no brake load, for main propulsion engines driving controllable pitch propellers.

The tests at the above-mentioned outputs are to be combined together in working cycles which are to be repeated in succession for the entire duration within the limits indicated.

The partial load tests are to be carried out along the nominal (theoretical) propeller curve and at constant speed.

For all the engines presenting power not superior than 2000 kW for which the approval of light duty and medium duty operating profile is requested a running test of 100 hours in cycles purposed by:

a) 8 hours at P_{MAX} e n_{MAX}

b) 30 min at 90% of P_{MAX}

c) 30 min at 70% of P_{MAX}

d) 30 min at 50% of P_{MAX}

e) 30 min at 25% of P_{MAX}

is to be carried out.

Partial loads in items b), c), d) and e) are to be achieved along the nominal curve (theory) of the propeller considered in quadratic function of rounds engine.

During the running test the parameters listed in [6.8.2] are to be noticed and recorded; at the end of the running test the crankshaft is to be dismantled and submitted to visual survey and non-destructive controls by the Surveyor in charge.

The running test mentioned above will be valid for the type test for engines admitted to alternative test.

Light duty and medium duty operating profiles are to reported in the approval and testing certificates.

7 Certification of engine components, workshop inspections and trials

7.1 General

7.1.1

The engine manufacturer is to have a quality control system that is suitable for the actual engine types to be certified by the Society. The quality control system is also to apply to any sub-suppliers. The Society re-serves the right to review the system or parts thereof. Materials and components are to be produced in compliance with all the applicable production and quality instructions specified by the engine manufacturer. The Society requires that certain parts are verified and documented by means of Society Certificate (SC), Work Certificate (W) or Test Report (TR).

a) The documents above are used for product documentation as well as for documentation of single inspections such as crack detection, dimensional check, etc. If agreed to by the Society, the documentation of single tests and inspections may also be arranged by filling in results on a control sheet following the component through the production.

b) The Surveyor is to review the TR and W for compliance with the agreed or approved specifications. SC means that the Surveyor also witnesses the testing, batch or individual, unless an ACS provides other arrangements.

c) The manufacturer is not exempted from responsibility for any relevant tests and inspections of those parts for which documentation is not explicitly requested by the Society. The manufacturing process and equipment is to be set up and maintained in such a way that all materials and components can be consistently produced to the required standard. This includes production and assembly lines, machining units, special tools and devices, assembly and testing rigs as well as all lifting and transportation devices.

7.2 Parts to be documented

7.2.1

The extent of parts to be documented depends on the type of engine, engine size and criticality of the part.

A summary of the required documentation for the engine components is listed in Tab 8.

Symbols used are listed in Tab 9.

Table 8 : Summary of required documentation for engine components *(1/1/2025)*

Item	Part **(6) (7) (8) (9)**	Material properties **(1)**	Non-destructive examination **(2)**	Hydrostatic test **(4)**	Dimensional inspection, including surface condition	Visual inspection (surveyor)	Applicable to engines:	Component certificate
1	Welded bedplate	W(C+M)	W(UT+CD)			fit-up + post-welding	All	SC
2	Bearing transverse girders GS	W(C+M)	W(UT+CD)			X	All	SC
3	Welded frame box	W(C+M)	W(UT+CD)			fit-up + post-welding	All	SC
4	Cylinder block GJL			W **(11)**			400 kW/cyl	
5	Cylinder block GJS			W **(11)**			400 kW/cyl	
6	Welded cylinder frames	W(C+M)	W(UT+CD)				CH	SC
7	Engine block GJL			W **(11)**			>400 kW/cyl	
8	Engine block GJS	W(M)		W **(11)**			>400 kW/cyl	
9	Cylinder liner	W(C+M)		W **(11)**			D>300mm	
10	Cylinder head GJL			W			D>300mm	
11	Cylinder head GJS			W			D>300mm	
12	Cylinder head GS	W(C+M)	W(UT+CD)	W		X	D>300mm	SC
13	Forged cylinder head	W(C+M)	W(UT+CD)	W		X	D>300mm	SC
14	Piston crown GS	W(C+M)	W(UT+CD)			X	D>400mm	SC

(1) Material properties include chemical composition and mechanical properties, and also surface treatment such as surface hardening (hardness, depth and extent), peening and rolling (extent and applied force).

(2) Non-destructive examination means e.g. ultrasonic testing, crack detection by MPI or DP. When certain NDE method on the
(3) finished component is impractical (for example UT for items 12/13), the NDE method can be performed at earlier appropriate stages in the production of the component, see [1.5.4].

(4) Hydrostatic test is applied on the water/oil side of the component. Items are to be tested by hydraulic pressure at the pressure equal to 1.5 times the maximum working pressure. High pressure parts of the fuel injection system are to be tested by hydraulic pressure at the pressure equal to 1.5 maximum working pressure or maximum working pressure plus 300 bar, whichever is the less. Where design or testing features may require modification of these test requirements, special consideration may be given.

(5) Material certification requirements for pumps and piping components are dependent on the operating pressure and temperature. Requirements given in this Table apply except where alternative requirements are explicitly given elsewhere in the Rule requirements.

(6) For turbochargers, see Sec 14.

(7) Crankcase explosion relief valves are to be type tested in accordance with App 5 of Tasneef Rules for The Classification of Ships and documented according to [4.3.4].

(8) Oil mist detection systems are to be type tested in accordance with App 6 of Tasneef Rules for The Classification of Ships and documented according to [4.3.5].

(9) For Speed governor and overspeed protective devices, see [4.7.3] to [4.7.6].

(10) Charge air coolers need only be tested on the water side.

(11) Hydrostatic test is also required for those parts filled with cooling water and having the function of containing the water which is in contact with the cylinder or cylinder liner.

Item	Part **(6) (7) (8) (9)**	Material properties **(1)**	Non-destructive examination **(2)**	Hydrostatic test **(4)**	Dimensional inspection, including surface condition	Visual inspection (surveyor)	Applicable to engines:	Component certificate
15	Forged piston crown	W(C+M)	W(UT+CD)			X	D>400mm	SC
16	Crankshaft: made in one piece	SC(C+M)	W(UT+CD)		W	Random, of fillets and oil bores	All	SC
17	Semi-built crankshaft (Crankthrow, forged main journal and journals with flange)	SC(C+M)	W(UT+CD)		W	Random, of fillets and shrink fittings	All	SC
18	Exhaust gas valve cage			W			CH	
19	Piston rod	SC(C+M)	W(UT+CD)			Random	D>400mm CH	SC
20	Cross head	SC(C+M)	W(UT+CD)			Random	CH	SC
21	Connecting rod with cap	SC(C+M)	W(UT+CD)		W	Random, of all surfaces, in particular those shot peened	All	SC
22	Coupling bolts for crankshaft	SC(C+M)	W(UT+CD)		W	Random, of interference fit	All	SC
23	Bolts and studs for main bearings	W(C+M)	W(UT+CD)				D>300mm	
24	Bolts and studs for cylinder heads	W(C+M)	W(UT+CD)			TR of thread making	D>300mm	

(1) Material properties include chemical composition and mechanical properties, and also surface treatment such as surface hardening (hardness, depth and extent), peening and rolling (extent and applied force).

(2) Non-destructive examination means e.g. ultrasonic testing, crack detection by MPI or DP. When certain NDE method on the

(3) finished component is impractical (for example UT for items 12/13), the NDE method can be performed at earlier appropriate stages in the production of the component, see [1.5.4].

(4) Hydrostatic test is applied on the water/oil side of the component. Items are to be tested by hydraulic pressure at the pressure equal to 1.5 times the maximum working pressure. High pressure parts of the fuel injection system are to be tested by hydraulic pressure at the pressure equal to 1.5 maximum working pressure or maximum working pressure plus 300 bar, whichever is the less. Where design or testing features may require modification of these test requirements, special consideration may be given.

(5) Material certification requirements for pumps and piping components are dependent on the operating pressure and temperature. Requirements given in this Table apply except where alternative requirements are explicitly given elsewhere in the Rule requirements.

(6) For turbochargers, see Sec 14.

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(9) For Speed governor and overspeed protective devices, see [4.7.3] to [4.7.6].

(10) Charge air coolers need only be tested on the water side.

(11) Hydrostatic test is also required for those parts filled with cooling water and having the function of containing the water which is in contact with the cylinder or cylinder liner.

Item	Part **(6) (7) (8) (9)**	Material properties **(1)**	Non-destructive examination **(2)**	Hydrostatic test **(4)**	Dimensional inspection, including surface condition	Visual inspection (surveyor)	Applicable to engines:	Component certificate
25	Bolts and studs for connecting rods	W(C+M)	W(UT+CD)			TR of thread making	D>300mm	
26	Tie rod	W(C+M)	W(UT+CD)			Random	CH	SC
27	High pressure fuel injection pump body	W(C+M)		W			D>300mm	
		W(C+M)		TR			D<300mm	
28	High pressure fuel injection valves (only for those not autofretted)			W			D>300mm	
				TR			D<300mm	
29	High pressure fuel injection pipes including common fuel rail	W(C+M)		W for those that are not autofretted			D>300mm	
		W(C+M)		TR for those that are not autofretted			D<300mm	
30	High pressure common servo oil system	W(C+M)		W			D>300mm	
		W(C+M)		TR			D<300mm	
31	Cooler, both sides **(10)**	W(C+M)		W			D>300mm	

(1) Material properties include chemical composition and mechanical properties, and also surface treatment such as surface hardening (hardness, depth and extent), peening and rolling (extent and applied force).

(2) Non-destructive examination means e.g. ultrasonic testing, crack detection by MPI or DP. When certain NDE method on the

(3) finished component is impractical (for example UT for items 12/13), the NDE method can be performed at earlier appropriate stages in the production of the component, see [1.5.4].

(4) Hydrostatic test is applied on the water/oil side of the component. Items are to be tested by hydraulic pressure at the pressure equal to 1.5 times the maximum working pressure. High pressure parts of the fuel injection system are to be tested by hydraulic pressure at the pressure equal to 1.5 maximum working pressure or maximum working pressure plus 300 bar, whichever is the less. Where design or testing features may require modification of these test requirements, special consideration may be given.

(5) Material certification requirements for pumps and piping components are dependent on the operating pressure and temperature. Requirements given in this Table apply except where alternative requirements are explicitly given elsewhere in the Rule requirements.

(6) For turbochargers, see Sec 14.

(7) Crankcase explosion relief valves are to be type tested in accordance with App 5 of Tasneef Rules for The Classification of Ships and documented according to [4.3.4].

(8) Oil mist detection systems are to be type tested in accordance with App 6 of Tasneef Rules for The Classification of Ships and documented according to [4.3.5].

(9) For Speed governor and overspeed protective devices, see [4.7.3] to [4.7.6].

(10) Charge air coolers need only be tested on the water side.

(11) Hydrostatic test is also required for those parts filled with cooling water and having the function of containing the water which is in contact with the cylinder or cylinder liner.

Item	Part **(6) (7) (8) (9)**	Material properties **(1)**	Non-destructive examination **(2)**	Hydrostatic test **(4)**	Dimensional inspection, including surface condition	Visual inspection (surveyor)	Applicable to engines:	Component certificate
32	Accumulator	W(C+M)		W			All engines with accumulators with a capacity of > 0,5 l	
33	Piping, pumps, actuators, etc. for hydraulic drive of valves, if applicable	W(C+M)		W			>800 kW/cyl	
34	Engine driven pumps (oil, water, fuel, bilge) other than pumps referred to in item 27 and 33			W			>800 kW/cyl	
35	Bearings for main, crosshead, and crankpin	TR(C)	TR (UT for full contact between base material and bearing metal)		W		>800 kW/cyl	

(1) Material properties include chemical composition and mechanical properties, and also surface treatment such as surface hardening (hardness, depth and extent), peening and rolling (extent and applied force).
(2) Non-destructive examination means e.g. ultrasonic testing, crack detection by MPI or DP. When certain NDE method on the
(3) finished component is impractical (for example UT for items 12/13), the NDE method can be performed at earlier appropriate stages in the production of the component, see [1.5.4].
(4) Hydrostatic test is applied on the water/oil side of the component. Items are to be tested by hydraulic pressure at the pressure equal to 1.5 times the maximum working pressure. High pressure parts of the fuel injection system are to be tested by hydraulic pressure at the pressure equal to 1.5 maximum working pressure or maximum working pressure plus 300 bar, whichever is the less. Where design or testing features may require modification of these test requirements, special consideration may be given.
(5) Material certification requirements for pumps and piping components are dependent on the operating pressure and temperature. Requirements given in this Table apply except where alternative requirements are explicitly given elsewhere in the Rule requirements.
(6) For turbochargers, see Sec 14.
(7) Crankcase explosion relief valves are to be type tested in accordance with App 5 of Tasneef Rules for The Classification of Ships and documented according to [4.3.4].
(8) Oil mist detection systems are to be type tested in accordance with App 6 of Tasneef Rules for The Classification of Ships and documented according to [4.3.5].
(9) For Speed governor and overspeed protective devices, see [4.7.3] to [4.7.6].
(10) Charge air coolers need only be tested on the water side.
(11) Hydrostatic test is also required for those parts filled with cooling water and having the function of containing the water which is in contact with the cylinder or cylinder liner.

Table 9 : Symbols used in Table 8

Symbol	Description
C	chemical composition
CD	crack detection by MPI or DP
CH	crosshead engines
D	cylinder bre diameter (mm)

Symbol	Description
GJL	gray cast iron
GJS	spheroidal graphite cast iron
GS	cast steel
M	mechanical properties
SC	society certificate
TR	test report
UT	ultrasonic testing
W	work certificate
X	visual examination of accessible surfaces by the Surveyor

7.3 Hydrostatic tests

7.3.1

In addition to what indicated in Tab 8, pressure pipes, valves and other fittings (used for water, lubricating oil, fuel oil, compressed air and other fluid), are to be subjected to hydrostatic tests at 1,5 times the maximum working pressure, but not less than 0,4 MPa.

7.4 Workshop inspections and testing

7.4.1

In addition to the type test, diesel engines are to be subjected to works trials, which are to be witnessed by the Surveyor except where an Alternative Certification Scheme has been granted or where otherwise decided by the Society on a case by case basis.

Engines which are to be subjected to trials on the test bed at the Manufacturer's works and under the Society's supervision are to be tested in accordance with the scope as specified below.

Exceptions to this require the agreement of the Society.

Before any official testing, the engines shall be run-in as prescribed by the engine manufacturer.

Adequate test bed facilities for loads as required in [7.4.4] shall be provided. All fluids used for testing purposes such as fuel, lubrication oil and cooling water are to be suitable for the purpose intended, e.g. they are to be clean, preheated if necessary and cause no harm to engine parts. This applies to all fluids used temporarily or repeatedly for testing purposes only.

On occasion of the workshop testing, engines are to be inspected for:

- Jacketing of high-pressure fuel oil lines including the system used for the detection of leakage.
- Screening of pipe connections in piping containing flammable liquids.
- Insulation of hot surfaces by taking random temperature readings that are to be compared with corresponding readings obtained during the type test. This shall be done while running at the rated power of engine. Use of contact thermometers may be accepted at the discretion of the attending Surveyor. If the insulation is modified subsequently to the Type Approval Test, the Society may request temperature measurements as required in [6.10.9].
- Presence of sensors for the alarms and safeguards required in Tab 4, Tab 5 and Tab 6 as applicable; and relevant functionality as far as possible.

These inspections are normally to be made during the works trials by the manufacturer and the attending surveyor, but at the discretion of the Society parts of these inspections may be postponed to the board testing.

Engines for which an Alternative Certification Scheme has been agreed with the Manufacturer are to be subjected to trials at the Manufacturer's works in accordance with a procedure previously accepted on a case-by-case basis by the Society and recorded in the documentation relevant to the admission to the Alternative Certification Scheme.

7.4.2 Objectives

The purpose of the works trials is to verify design premises such as power, safety against fire, adherence to approved limits (e.g. maximum pressure), and functionality and to establish reference values or base lines for later reference in the operational phase.

7.4.3 Records

a) The following environmental test conditions are to be recorded:
   1) Ambient air temperature
   2) Ambient air pressure
   3) Atmospheric humidity

b) For each required load point, the following parameters are normally to be recorded:
   - Power and speed
   - Fuel index (or equivalent reading)
   - Maximum combustion pressures (only when the cylinder heads installed are designed for such measurement).
   - Exhaust gas temperature before turbine and from each cylinder (to the extent that monitoring is required in Sec 14 and [4.7.9].
   - Charge air temperature
   - Charge air pressure
   - Turbocharger speed (to the extent that monitoring is required in Sec 14.

c) Calibration records for the instrumentation are, upon request, to be presented to the attending Surveyor.

d) For all stages at which the engine is to be tested, the pertaining operational values are to be measured and recorded by the engine manufacturer. All results are to be compiled in an acceptance protocol to be issued by the engine manufacturer. This also includes crankshaft deflections if considered necessary by the engine designer.

e) In each case, all measurements conducted at the various load points are to be carried out at steady state operating conditions. However, for all load points provision should be made for time needed by the Surveyor to carry out visual inspections. The readings for MCR, i.e. 100% power (rated maximum continuous power at corresponding rpm) are to be taken at least twice at an interval of normally 30 minutes.

7.4.4 Test loads *(1/1/2025)*

Test loads for various engine applications are given below. In addition, the scope of the trials may be expanded depending on the engine application, service experience, or other relevant reasons.

Note 1: Alternatives to the detailed tests may be agred between the manufacturer and the Society when the overall scope of tests is found to be equivalent.

a) Propulsion engines driving propeller or impeller only
   1) 100% power (MCR) at corresponding speed n_0: at least 60 min.
   2) 110% power at engine speed $1.032n_0$: Records to be taken after 15 minutes or after steady conditions have been reached, whichever is shorter.

Note 2: Only required once for each different engine/turbocharger configuration and in general is not required for medium and light duty.

   3) Approved intermittent overload (if applicable): testing for duration as agreed with the manufacturer.
   4) 90% (or normal continuous cruise power), 75%, 50% and 25% power in accordance with the nominal propeller curve, the sequence to be selected by the engine manufacturer.
   5) Reversing manoeuvres (if applicable).

Note 3: After running on the test bed, the fuel delivery system is to be so adjusted that overload power cannot be given in service, unless intermittent overload power is approved by the Society. In that case, the fuel delivery system is to be blocked to that power.

b) Engine driving generators for electric propulsion
   1) 100% power (MCR) at corresponding speed no.: at least 60 min.
   2) 110% power at engine speed n_0: 15 min. - after having reached steady conditions.
   3) Governor tests for compliance with [4.7.3] and [4.7.5] are to be carried out.
   4) 75%, 50% and 25% power and idle, the sequence to be selected by the engine manufacturer.

Note 4: After running on the test bed, the fuel delivery system is to be adjusted so that full power plus a 10% margin for transient regulation can be given in service after installation onboard.

The transient overload capability is required so that the required transient governing characteristics are achieved also at 100% loading of the engine, and also so that the protection system of the electric distribution system can be activated before the engine stalls.

c) Engines driving generators for auxiliary purposes

   Tests to be performed as per b)

d) Propulsion engines also driving power take off (PTO) generator
   1) 100% power (MCR) at corresponding speed no.: at least 60 min.
   2) 110% power at engine speed n°: 15 min. - after having reached steady conditions.
   3) Approved intermittent overload (if applicable): testing for duration as agreed with the manufacturer.
   4) 90% (or normal continuous cruise power), 75%, 50% and 25% power in accordance with the nominal propeller curve or at constant speed no., the sequence to be selected by the engine manufacturer.

Note 5: After running on the test bed, the fuel delivery system is to be adjusted so that full power plus a margin for transient regulation can be given in service after installation onboard. The transient overload capability is required so that the electrical protection of downstream system components is activated before the engine stalls. This margin may be 10% of the engine power but at least 10% of the PTO power.

e) Engines driving auxiliaries
   1) 100% power (MCR) at corresponding speed no.: at least 30 min.
   2) 110% power at engine speed n°: 15 min. - after having reached steady conditions.
   3) Approved intermittent overload (if applicable): testing for duration as agreed with the manufacturer.
   4) For variable speed engines, 75%, 50% and 25% power in accordance with the nominal power consumption curve, the sequence to be selected by the engine manufacturer.

Note 6: After running on the test bed, the fuel delivery system is to be so adjusted that overload power cannot be given in service, unless intermittent overload power is approved by the Society. In that case, the fuel delivery system is to be blocked to that power.

7.4.5 Turbocharger matching with engine

a) Compressor chart

   Turbochargers shall have a compressor characteristic that allows the engine, for which it is intended, to operate without surging during all operating conditions and also after extended periods in operation.

   For abnormal, but permissible, operation conditions, such as misfiring and sudden load reduction, no continuous surging shall occur.

   In this section, surging and continuous surging are defined as follows:

   - Surging means the phenomenon, which results in a high pitch vibration of an audible level or explosion-like noise from the scavenger area of the engine.
   - Continuous surging means that surging happens repeatedly and not only once.

b) Surge margin verification

   Category C turbochargers used on propulsion engines are to be checked for surge margins during the engine workshop testing as specified below. These tests may be waived if successfully tested earlier on an identical configuration of engine and turbocharger (including same nozzle rings).

   - For 4-stroke engines:

     The following shall be performed without indication of surging:

     - With maximum continuous power and speed (=100%), the speed shall be reduced with constant torque (fuel index) down to 90% power.
     - With 50% power at 80% speed (= propeller characteristic for fixed pitch), the speed shall be reduced to 72% while keeping constant torque (fuel index).
   - For 2 stroke engines:

     The surge margin shall be demonstrated by at least one of the following methods:

     - The engine working characteristic established at workshop testing of the engine shall be plotted into the compressor chart of the turbocharger (established in a test rig). There shall be at least 10% surge margin in the full load range, i.e. working flow shall be 10% above the theoretical (mass) flow at surge limit (at no pressure fluctuations).
     - Sudden fuel cut-off to at least one cylinder shall not result in continuous surging and the turbocharger shall be stabilized at the new load within 20 seconds. For applications with more than one turbocharger the fuel shall be cut-off to the cylinders closest upstream to each turbocharger.

       This test shall be performed at two different engine loads:

       - The maximum power permitted for one cylinder misfiring.
       - The engine load corresponding to a charge air pressure of about 0.6 bar (but without auxiliary blowers running).
     - No continuous surging is to occur and the turbocharger shall be stabilized at the new load within 20 seconds when the power is abruptly reduced from 100% to 50% of the maximum continuous power.

7.4.6 Integration tests

For electronically controlled engines, integration tests are to be made to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes and the tests considered as a system are to be carried out at the works. If such tests are technically unfeasible at the works, however, these tests may be conducted during sea trial. The scope of these tests is to be agreed with the Society for selected cases based on the FMEA required in Tab 1.

7.4.7 Component inspections

Random checks of components to be presented for inspection after works trials are to be selected by the Manufacturer or by the Surveyor if the works trials are witnessed.

8 Certification

8.1 Testing certification

8.1.1

a) Engines admitted to an Alternative Certification Scheme

   Work’s Certificate (W) (see [1.5.5] and Pt D, Ch 1, Sec 1, [4.2.3]) is required for components and tests indicated in Tab 8 and for works trials as per [7.4]. In this case, a Work’s Certificate (W) may be considered equivalent to a Society Certificate (SC) and endorsed by the Society.

b) Engines not admitted to an Alternative Certification Scheme

   Society Certificate (SC) (see [1.5.4] and Pt D, Ch 1, Sec 1, [4.2.1]) is required for components and tests indicated in Tab 8 and for works trials as per [7.4], in addition to other Work's Certificates (W) indicated in Tab 8.

In both cases a) and b), the Manufacturer is to supply:

a) the following information:
   - engine type
   - rated power
   - rated speed
   - driven equipment
   - operating conditions
   - list of auxiliaries fitted on the engine

b) a statement certifying that the engine is in compliance with that type tested. The reference number and date of Certificate are also to be indicated in the statement.

SECTION 3 GAS TURBINES

1 General

1.1 Application

1.1.1 Propulsion turbines and turbines for essential services

The requirements of this Section apply to:

a) all propulsion turbines

b) turbines intended for auxiliary services essential for safety and navigation.

[4] and [5] are applicable when requested in accordance with the relevant Table of Pt A, Ch 2, App 3.

1.1.2 Turbines for auxiliary generators

In addition to the requirements contained in this Section, auxiliary turbines driving electric generators are to comply with the applicable requirements of Chapter 2 of the Rules.

1.1.3 Type approval

Turbines intended for propulsion and essential services are to be type approved by the Society.

1.2 Definition of rated power

1.2.1 Rated power is the maximum constant power that the turbine can develop at constant speed in the range of air inlet temperature between 0°C and 35°C. This power is to be considered with 0 intake and exhaust losses and with an air relative humidity of 60%.

1.3 Documentation to be submitted

1.3.1 For propulsion turbines and turbines intended for driving machinery for essential services, the plans listed in Tab 1 are to be submitted.

The listed constructional plans are to be complete with all dimensions and are to contain full indication of the types of materials used.

2 Design and Construction

2.1 Materials

2.1.1 Approved materials

a) Gas turbine materials are to fulfil the requirements imposed by the operating conditions of the individual components. In the choice of materials, account is to be taken of effects such as creep, thermal fatigue, oxidation and corrosion to which individual components are subject when in service. Evidence of the suitability of the materials is to be supplied to the Society in the form of details of their chemical and mechanical properties and of the heat treatment applied. Where composite materials are used, their method of manufacture is to be described.

b) Turbine blades are to be built of corrosion and heat-resistant materials.

2.2 Stress analyses

2.2.1 Calculation

a) The manufacturer is to submit the results of calculation of the stresses on each rotor under the most severe service conditions.

b) Fatigue analysis on each rotor, taking into account the stress concentrations, is also to be submitted.

c) The results of previous in-service experience on similar applications may be considered by the Society as an alternative to items a) and b) above.

The calculations and analyses (see also [1.3.1]) are to be carried out in accordance with criteria agreed by the Society. Data on the design service life and test results used to substantiate calculation assumptions are also to be provided.

2.2.2 Vibrations

The range of service speeds is not to give rise to unacceptable bending vibrations or to vibrations affecting the entire installation. Calculations of the critical speeds including details of their basic assumptions are to be submitted.

2.3 Design and constructional details

2.3.1 Rotors and stators

a) All components of turbines and compressors are to be free from defects and are to be built and installed with tolerances and clearances in order to allow thermal expansion and to minimise the distortions of casings and rotors in all expected service conditions.

b) Adequate drain tubes and cocks are to be arranged in a suitable position, in the lower parts of the casings. Cocks are to be easily operated.

c) Suitable protective devices are to be provided in order to prevent heat, noise or possible failure of rotating parts from causing injury to personnel. If, to this end, the whole gas turbine is enclosed in a protective covering, the covering is to be adequately ventilated inside.

d) Particular attention is to be paid to the connection in the casings of pipes to the turbine stators in order to avoid abnormal loads in service.

e) Smooth fillets are to be provided at changes of sections of rotors, discs and blade roots. The holes in discs are to be well rounded and polished.

Table 1 : Documents to be submitted

No.	A/I **(1)**	ITEM
1	I	Sectional assembly
2	A	Detailed drawings of rotors, casings, blades, combustion chambers and heat exchangers **(2)**
3	A	Material specifications of the major parts, including their physical, chemical and mechanical properties, the data relevant to rupture and creep at elevated temperatures, the fatigue strength, the corrosion resistance and the heat treatments **(2)**
4	A	Where the rotors, stators or other components of turbines are of welded construction, all particulars on the design of welded joints, welding procedures and sequences, heat treatments and non-destructive examinations after welding **(2)**
5	I	General specification of the turbine, including instruction manual, description of structures and specification of the properties of fuel and lubricating oil to be used
6	I	Details of operating conditions, including the pressure and temperature curves in the turbine and compressor at the rated power and corresponding rotational speeds, and details of permissible temporary operation beyond the values for the rated power
7	A	Diagrammatic layout of the fuel system, including control and safety devices, and of the lubricating oil system
8	A	Cooling system layout, if applicable
9	I	Where applicable, background information on previous operating experience in similar applications
10	I	Maintenance and overhaul procedures
11	A	Stress and temperature analysis in blades, rotors and combustion chamber **(2)**
12	A	Life time calculation of hot and high stress parts **(2)**
13	A	Blade and rotor vibration analysis **(2)**
14	A	Details of automatic safety devices together with failure mode and effect analysis (FMEA) **(2)**

(1) A = to be submitted for approval in four copies
I = to be submitted for information in duplicate

(2) As an alternative, the Society may, on a case by case basis, consider reviewing a number of selected packages relative to important and critical parts of the turbine, where all the design, construction, inspection, testing and acceptance criteria used by the manufacturer are clearly described, provided the Quality Assurance system of the manufacturer is approved and certified by the Society.

2.3.2 Access and inspection openings

a) Access to the combustion chambers is to be ensured. Means are to be provided to inspect the burner cans or combustion chamber without having to remove the gas generator.

b) Inspection openings are to be provided to allow the gas turbine flow path air to be inspected with special equipment, e.g. a bore-scope or similar, without the need for dismantling.

2.3.3 Bearings

a) Turbine bearings are to be so located that their lubrication is not impaired by overheating from hot gases or adjacent hot parts.

b) Lubricating oil or fuel oil is to be prevented from dripping on high temperature parts.

c) Suitable arrangements for cooling the bearings after the turbines have been stopped are to be provided, if necessary to prevent bearing cooking.

d) Roller bearings are to be identifiable and are to have a life adequate for their intended purpose. In any event, their life cannot be less than 40000 hours.

2.3.4 Turning gear

a) Main propulsion turbines are to be equipped with turning gear or a starter for cranking. The rotors of auxiliary turbines are to be capable of being turned by hand.

b) The engagement of the turning gear or starter is to be visually indicated at the control platform.

c) An interlock is to be provided to ensure that the main turbine cannot be started up when the turning gear is engaged.

2.3.5 Cooling

The turbines and their external exhaust system are to be suitably insulated or cooled to avoid excessive outside temperature.

2.3.6 Air supply

a) The air intake ducting is to be equipped to prevent extraneous substances from entering the compressor and turbine.

b) Measures are to be taken to control the salinity of the combustion air, to meet the manufacturer’s specification.

c) Cleaning equipment is to be provided to remove deposits from compressors and turbines.

d) Means are to be provided to prevent the formation of ice in the air intake.

2.3.7 Turbine exhaust arrangement

a) The gas exhaust arrangement is to be designed in such a way as to prevent the entrance of gases into the compressor.

b) Silencers or other equivalent arrangements are to be provided in the gas exhaust, to limit the airborne noise at one metre distance from the turbine to not more than 110 dB (A) in unmanned machinery spaces and not more than 90 dB (A) in manned spaces.

2.3.8 Multi-turbine installations

Multi-turbine installations are to have separate air inlets and exhaust systems to prevent recirculation through the idle turbine.

2.3.9 Fuel *(1/1/2025)*

a) Where the turbine is designed to burn non-distillate fuels, a fuel treatment system is to be provided to remove, as far as practicable, the corrosive constituents of the fuel or to inhibit their action in accordance with the manufacturer’s specification.

b) Suitable means are to be provided to remove the deposits resulting from the burning of the fuel while avoiding abrasive or corrosive action, if applicable.

2.3.10 Start-up equipment

a) Gas turbines are to be fitted with start-up equipment enabling them to be started up from the "shutdown" condition.

b) Provisions are to be made so that any dangerous accumulation of liquid or gaseous fuel inside the turbines is thoroughly removed before any attempt at starting or restarting.

c) Starting devices are to be so arranged that firing operation is discontinued and the main fuel valve is closed within a pre-determined time when ignition is failed.

d) The minimum number of starts is to be such as to satisfy the requirements of Sec 1, [1.4.4].

2.3.11 Astern power

For main propulsion machinery with reverse gearing, controllable pitch propellers or an electrical transmission system, astern running is not to cause any overloading of the propulsion machinery.

2.3.12 Emergency operation

a) In installations with more than one propeller and connected shafting and more than one turbine, the failure of any gas turbine unit connected to a shafting line is not to affect the continued, independent operation of the remaining units.

b) In installations with only one propeller and connected shafting, driven by two or more main turbines, care is to be taken to ensure that, in the event of one of the turbines failing, the others are able to continue operation independently.

c) Yachts classed for unrestricted service and fitted with only one propeller and connected shafting driven by a gas turbine are to be provided with means to ensure emergency propulsion in the event of failure of the main turbine.

2.4 Welded fabrication

2.4.1 The manufacturer's requirements relative to the welding of turbine rotors or major forged or cast pieces, where permitted, are to be readily identifiable by the Society in the plans submitted for approval.

In general, all weldings are to be carried out by qualified welders in accordance with qualified welding procedures using approved consumables.

2.5 Control and monitoring

2.5.1 General

In addition to those of this item [2.5], the general requirements given in Chapter 3 apply.

In the case of yachts with automation notations, the requirements in Part F, Chapter 2 also apply.

2.5.2 Governors and speed control system

a) Propulsion turbines which may be operated in no-load conditions are to be fitted with a control system capable of limiting the speed to a value not exceeding 10% of the maximum continuous speed.

b) Turbines for main propulsion machinery equipped with controllable pitch propellers, disengaging couplings or an electrical transmission system are to be fitted with a speed governor which, in the event of a sudden loss of load, prevents the revolutions from increasing to the trip speed.

c) In addition to the speed governor, turbines driving electric generators are to be fitted with a separate overspeed protective device, with a means for manual tripping, adjusted so as to prevent the rated speed from being exceeded by more than 15%.

d) The speed increase of turbines driving electric generators - except those for electrical propeller drive - resulting from a change from full load to no-load is not to exceed 5% on the resumption of steady running conditions. The transient speed increase resulting from a sudden change from full load to no-load conditions is not to exceed 10% and is to be separated by a sufficient margin from the trip speed. Alternative requirements may be considered by the Society on a case by case basis based on the actual turbine design and arrangement.

2.5.3 Monitoring system

The main operating parameters (pressure, temperature, rpm, etc.) are to be adequately monitored and displayed at the control console.

2.5.4 Emergency shut-off

a) An emergency push-button shut-off device is to be provided at the control console.

b) Any shut-off device provided in pursuance of the above is to shut off the fuel supply as near the burners as possible.

2.5.5 Quick-closing devices

a) Re-setting of the quick-closing device may be effected only at the turbine or from the control platform with the fuel supply control valve in the closed position.

b) When the devices are operated by hydraulic oil systems fitted for automatic operation, they are to be fed by two pumps: one main pump and one standby pump. In any event, the standby pump is to be independent. In special cases, a hand-operated pump may be accepted as a standby pump.

c) The starting up of any turbine is to be possible only when the quick-closing devices are ready for operation.

2.5.6 Automatic temperature controls

The following turbine services are to be fitted with automatic temperature controls so as to maintain steady state conditions within the normal operating range of the main gas turbine:

a) lubricating oil supply and discharge

b) fuel oil supply (or, alternatively, automatic control of fuel oil viscosity)

c) exhaust gas in specific locations of the flow gas path as determined by the manufacturer.

2.5.7 Summary table

Tab 2 indicates the minimum control, monitoring and shutdown requirements for main propulsion and auxiliary turbines.

Unless the FMEA required in this Section proves otherwise, the shutdown functions for gas turbines are to be provided in accordance with Tab 2.

Although in principle alarming devices listed in Tab 2 are to be provided, they can be added or omitted, taking into account the result of FMEA.

Note 1: Some departures from Tab 2 may be accepted by the Society in the case of yachts with short range navigation notation.

Table 2 : Main propulsion and auxiliary turbines

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Turbine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
• Control system failure	X						
• Automatic starting failure	X						
Mechanical monitoring of gas turbine							
• Speed		local					
					X		
	H			X			
• Rotor axial displacement (Not applicable to roller bearing)		local					
	H			X			
• Vibration	H*	local		X			
• Performed number of cycle of rotating part	H						
Gas generator monitoring							
• Flame and ignition failure	X			X			
• Fuel oil supply pressure	L	local					
• Fuel oil supply temperature	H	local					
• Cooling medium temperature	H	local					
• Exhaust gas temperature or gas temperature in specific locations of flow gas path. (Alarm before shutdown)		local					
	H*			X			
• Vacuum pressure at the compressor inlet (alarm before shutdown)		local					
	H*			X			
Lubricating oil							
• Turbine supply pressure		local					
	L*			X			
• Lubricating oil pressure of reduction gear		local					
	L*			X			
• Differential pressure across lubricating oil filter	H	local					

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Turbine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
• Bearing or lubricating oil (discharge) temperature	H	local					
Notes: 1) Alarms marked with “*” are to be activated at the suitable setting points prior to arriving the critical condition for the activation of shutdown devices.							

3 Arrangement and installation

3.1 Foundations

3.1.1 Foundations of turbines and connected reduction gears are to be designed and built so that hull movements do not give rise to significant movements between reduction gears and turbines. In any event, such movements are to be absorbed by suitable couplings.

3.2 Joints of mating surfaces

3.2.1 The mating flanges of casings are to form a tight joint without the use of any interposed material.

3.3 Piping installation

3.3.1 Pipes and mains connected to turbine and compressor casings are to be fitted in such a way as to minimise the thrust loads and moments. If flexible hoses are used for this purpose, they are to comply with the requirements in Sec 10, [2.6].

3.4 Hot surfaces

3.4.1 Hot surfaces with which the crew are likely to come into contact during operation are to be suitably guarded or insulated. See Sec 1, [3.7].

3.5 Alignment

3.5.1

a) Particular care is to be taken in the alignment of turbine-reduction gearing, taking account of all causes which may alter the alignment from cold conditions to normal service conditions.

b) When a structural tank is fitted in way of the turbine or gearing foundations, the expected tank temperature variations are to be taken into account during alignment operations.

c) Propulsion turbines are to be fitted with indicators showing the axial movements of rotors with respect to casings and the sliding movements of casings on the sliding feet. Such indicators are to be fitted in an easily visible position. This requirement does not apply to turbines fitted with roller bearings.

3.6 Gratings

3.6.1 Gratings and any other structures in way of the sliding feet or flexible supports are to be so arranged that turbine casing expansion is not restricted.

3.7 Drains

3.7.1 Turbines and the associated piping systems are to be equipped with adequate means of drainage.

3.8 Instruments

3.8.1 Main and auxiliary turbines are to be fitted with callipers and micrometers of a suitable type for verifying the alignment of rotors and pinion and gear-wheel shafts, when necessary.

At the time of installation on board, this check is to be performed in the presence and to the satisfaction of the Surveyor.

4 Material tests, workshop inspection and testing, certification

4.1 Type tests - General

4.1.1 Upon finalisation of the design for production of every new turbine type intended for installation on board, one turbine is to be presented for type testing as required below.

A type test carried out for a particular type of turbine at any manufacturer's works will be accepted for all turbines of the same type built by licensees and licensors.

Turbines which are subjected to type testing are to be tested in accordance with the scope specified below, it being taken for granted that:

- the turbine is optimised as required for the conditions of the type test
- the investigations and measurements required for reliable turbine operation have been carried out during preliminary internal tests by the turbine manufacturer
- the documentation to be submitted as required in [1.3.1] has been examined and, when necessary, approved by the Society and the latter has been informed regarding the nature and extent of investigations carried out during pre-production stages.

4.2 Type tests of turbines not admitted to an Alternative Certification Scheme

4.2.1 General

Turbines for which the Manufacturer is not admitted to testing and inspections according to an Alternative Certification Scheme (see Pt D, Ch 1, Sec 1, [3.2]), are to be type tested in the presence of the Surveyor in accordance with the following requirements.

The type test is subdivided into three stages:

a) Stage A - Preliminary internal tests carried out by the manufacturer

   Stage A includes functional tests and collection of operating values including testing hours during the internal tests, the relevant results of which are to be presented to the Surveyor during the type test. Testing hours of components which are inspected are to be stated by the manufacturer.

b) Stage B - Type approval test

   The type approval test is to be carried out in the presence of the Surveyor.

c) Stage C - Inspection of main turbine components

   After completion of the test programme, the main turbine components are to be inspected.

The turbine manufacturer is to compile all results and measurements for the turbine tested during the type test in a type test report, which is to be submitted to the Society.

4.2.2 Stage A - Internal tests (functional tests and collection of operating data)

a) During the internal tests the turbine is to be operated at the load points considered important by the turbine manufacturer and the relevant operating values are to be recorded.

b) The load points may be selected according to the range of application.

c) Functional tests under normal operating conditions include:

   1) The load points 25%, 50%, 75%, 100% of the rated power for which type approval is requested, to be carried out:
      - along the nominal (theoretical) propeller curve and at constant speed, for propulsion turbines
      - at constant speed, for turbines intended for generating sets.

   2) The limit points of the permissible operating range.

      These limit points are to be defined by the turbine manufacturer.

d) An alternative testing program may be agreed between the manufacturer and the Society on a case by case basis.

4.2.3 Stage B - Type approval tests in the presence of the Surveyor

During the type test, the tests listed below are to be carried out in the presence of the Surveyor and the results are to be recorded in a report signed by both the turbine manufacturer and the Surveyor.

Any departures from this programme are to be agreed upon by the manufacturer and the Society.

a) Load points

   The load points at which the turbine is to be operated according to the power/speed diagram are those listed below. The data to be measured and recorded when testing the turbine at various load points are to include all necessary parameters for turbine operation.

The operating time per load point depends on the turbine characteristics (achievement of steady-state condition) and the time for collection of the operating values.

Normally, an operating time of 0,5 hour per load point can be assumed.

At the maximum continuous power as per the following item (1) an operating time of two hours is required. Two sets of readings are to be taken at a minimum interval of one hour.

1) test at maximum continuous power P: i.e. 100% output at 100% torque and 100% speed.
2) test at maximum permissible torque (normally 110% of nominal torque T) at 100% speed; or test at maximum permissible power and speed according to the nominal propeller curve.
3) tests at partial loads, e.g. 75%, 50%, 25% of maximum continuous power P and speed according to the nominal propeller curve.

b) Additional tests
   - test at lowest turbine speed according to the nominal propeller curve
   - starting tests
   - governor tests
   - testing and rating of the safety systems.

4.2.4 Evaluation of test results

The results of the tests and checks required by [4.2.3] will be evaluated by the attending Surveyor. Normally the main operating data to be recorded during the tests are those listed in [4.3.4].

The values of temperatures and pressures of media, such as cooling media, lubricating oil, exhaust gases, etc., are to be within limits which, in the opinion of the Surveyor, are appropriate for the characteristics of the turbine tested.

4.2.5 Stage C - Inspection of turbine components

Immediately after the test run as per [4.2.3], a selected number of components agreed between the manufacturer and the Society are to be presented for inspection to the Surveyor.

4.3 Type tests of turbines admitted to an Alternative Certification Scheme

4.3.1 General

Turbines admitted to testing and inspections according to an Alternative Certification Scheme (see Pt D, Ch 1, Sec 1, [3.2]) are to be type tested in the presence of the Surveyor in accordance with the following requirements.

The selection of the turbine to be tested from the production line is to be agreed upon with the Surveyor.

4.3.2 Type test

The programme of the type test is to be in general as specified below, P being the rated power and n the corresponding speed.

Any departures from this programme are to be agreed upon by the manufacturer and the Society.

a) 6 hours at full power
b) 10 hours shared at different partial loads (25%, 50%, 75% and 90% of power P);
c) 2 hours at intermittent loads
d) starting tests
e) testing of speed governor, overspeed device and lubricating oil system failure alarm device
f) testing of the minimum speed along the nominal (theoretical) propeller curve, for main propulsion turbines driving fixed pitch propellers, and of the minimum speed with no brake load, for main propulsion turbines driving controllable pitch propellers or for auxiliary turbines.

The tests at the above-mentioned outputs are to be combined together in working cycles which are to be repeated in succession for the entire duration within the limits indicated.

In particular, the full power test is to be carried out at the end of each cycle.

The partial load tests specified in (b) are to be carried out:

- along the nominal (theoretical) propeller curve and at constant speed, for propulsion turbines
- at constant speed, for turbines intended for generating sets.

In the case of prototype turbines, the duration and programme of the type test will be specially considered by the Society.

4.3.3 Alternatives

In cases of turbines for which the manufacturer submits documentary evidence proving successful service experience or results of previous bench tests, the Society may, at its discretion, allow a type test to be carried out, in the presence of the Surveyor according to a programme to be agreed upon in each instance.

4.3.4 Data to be recorded

During the type test, at least the following particulars are to be recorded:

a) ambient air temperature, pressure and atmospheric humidity in the test room
b) cooling medium temperature at the inlet of the turbine
c) characteristics of the fuel and lubricating oil used during the test
d) turbine speed
e) brake power
f) brake torque
g) intake and exhaust losses
h) lubricating oil pressure and temperature
i) exhaust gas temperature in locations of the flow gas path selected by the manufacturer
j) minimum starting air pressure and flow rate necessary to purge and start the turbine in cold condition, if applicable.

4.3.5 Inspection of main turbine components and evaluation of test results

The provisions of [4.2.4] and [4.2.5] are to be complied with, as far as applicable.

4.4 Material tests

4.4.1 The materials for the construction of the parts listed in Tab 3 are to be tested in compliance with the requirements of Part D.

Magnetic particle or liquid penetrant tests are required for the parts listed in Tab 3 and are to be effected in positions mutually agreed upon by the manufacturer and the Surveyor, where experience shows defects are most likely to occur.

For important structural parts of the turbine, in addition to the above-mentioned non-destructive tests, examination of welded seams by approved methods of inspection may be required.

Where there is evidence to doubt the soundness of any turbine component, non-destructive tests using approved detecting methods may be required.

4.5 Inspections and testing during construction

4.5.1 Inspections during construction

The following inspections and tests are to be carried out in the presence of a Surveyor during the construction of all turbines which are indicated in [1.1.1]. For on-board trials see Sec 16, [3.6].

- Material tests as required (See [4.4]).
- Welding fabrication (See [4.5.2]).
- Hydrostatic tests (See [4.5.3]).
- Rotor balancing and overspeed test (See [4.5.4], [4.5.5]).
- Shop trials (See [4.5.6]).

4.5.2 Welding fabrication

Welding fabrication and testing is to be attended by the Surveyor, as may be deemed necessary by the Society.

4.5.3 Hydrostatic tests

Finished casing parts and heat exchangers are to be subjected to hydrostatic testing at 1,5 times the maximum permissible working pressure. If it is demonstrated by other means that the strength of casing parts is sufficient, a tightness test at 1,1 times the maximum permissible working pressure may be accepted by the Society. Where the hydrostatic test cannot be performed, alternative methods for verifying the integrity of the casings may be agreed between the manufacturer and the Society on a case by case basis.

4.5.4 Balancing of rotors

Finished rotors, complete with all fittings and blades, are to be dynamically balanced in a balancing machine of appropriate sensitivity in relation to the size of the rotor. Normally this test is to be carried out with the primary part of the flexible coupling, if any.

4.5.5 Overspeed test of rotors

Finished rotors, complete with all fittings and blades, are to be subjected for at least 3 minutes to an overspeed test at the greater of the following values:

- 5% above the setting speed of the overspeed tripping device
- 15% above the maximum design speed.

The Society may waive this requirement provided that it can be demonstrated by the manufacturer, using an acceptable direct calculation procedure, that the rotor is able to safely withstand the above overspeed values and that rotors are free from defects, as verified by means of non-destructive tests.

4.5.6 Shop trials

For shop trials, see [4.2.3] and [4.3.2].

4.6 Certification

4.6.1 Type approval certificate and its validity

Subject to the satisfactory outcome of the type tests and inspections specified in [4.2] or [4.3], the Society will issue to the turbine manufacturer a "Type Approval Certificate" valid for all turbines of the same type.

4.6.2 Testing certification

a) Turbines admitted to an Alternative Certification Scheme

Work’s Certificate (W) (see Pt D, Ch 1, Sec 1, [4.2.3]) is required for components and tests indicated in Tab 3 and tests and trials listed in [4.5.1]. However, the Society reserves the right to request that the shop trials be witnessed by a Surveyor on a case by case basis.

b) Turbines not admitted to an Alternative Certification Scheme

Society Certificate (C) (see Pt D, Ch 1, Sec 1, [4.2.1]) is required for material tests of rotating components and blades listed in Tab 3 and for works trials as per [4.5.3] and [4.5.4].

Work’s Certificate (W) (see Pt D, Ch 1, Sec 1, [4.2.3]) is required for the other items listed in Tab 3 and for trials described in [4.5.2] [4.5.5] and [4.5.6].

Table 3 : Material and non-destructive tests

Turbine component	Material tests (Mechanical properties and chemical composition)	Non-destructive tests	
		Magnetic particle or liquid penetrant	Ultrasonic or radiographic examination
Rotating parts (compressors and turbine rotors, shafts, stiff and flexible couplings, bolts for couplings and other dynamically stressed parts, integral pinions and gears)	all	all	all
Stationary parts (castings for casings intended for a temperature exceeding 230°C and plates for casings intended for a temperature exceeding 370°C or pressure exceeding 4 Mpa)	all	spot as agreed between the Manufacturer and the Surveyor	-
Blades	sample	sample	sample
Piping and associated fittings	as required in the appropriate section of the Rules	as required in the appropriate section of the Rules	as required in the appropriate section of the Rules

SECTION 4 YACHTS FUELLED WITH ALTERNATIVE FUELS

1 General

1.1 Type of gases/fuels

1.1.1 Yachts propelled by alternative fuels are:

a) Gas Fuelled Yachts;

b) LPG or NH_3 Fuelled Yachts

c) Hydrogen Fuelled Yachts

d) Methanol/Ethanol Fuelled Yachts

e) Battery Powered Yachts

f) Yachts with Fuel Cells Installations

g) Biofuels

1.2 Application

1.2.1 The requirements for the verification of the projects of yachts propelled or powered by alternative fuels are the following:

a) Pt C, Ch 1, App 7 of Tasneef Rules for The Classification of Ships for Gas Fuelled Ships;

b) Pt C, Ch 1, App 13 of Tasneef Rules for The Classification of Ships for LPG or NH_3 Fuelled Ships

c) Pt C, Ch 1, App 14 of Tasneef Rules for The Classification of Ships for Hydrogen Fuelled Ships

d) Pt C, Ch 1, App 15 of Tasneef Rules for The Classification of Ships for Methanol/Ethanol Fuelled Ships

e) Pt C, Ch 1, App 12 of Tasneef Rules for The Classification of Ships for Safety of Internal Combustion Engines Supplied with Low Pressure Gas

f) Pt C, Ch 1, App 16 of Tasneef Rules for The Classification of Ships for Biofuel Ships

1.2.2 For Battery Powered Yachts reference is to be made to Ch.2 App.4.

1.2.3 For Fuel Cell Installation reference is to be made to Ch.2 App.5

1.2.4 The requirements in [1.2.1] have to be applied as far as it is practicable considering the size of the yacht after agreement with the Administration of the yacht

1.2.5 This section is to be red together with the International Regulatory framework for gases and flash point fuel installed on board of Ships (i.e SOLAS and IGF Code)

2 Approval Procedure

2.1 General

2.1.1 When facing new technologies and innovative yachting design solution, such as alternative fuels, arising from innovative solutions to reduce carbon emissions, improve carbon footprint, the following steps are to be followed:

a) Tasneef carries out a preliminary examination of the proposal

b) Tasneef, Shipyard and/or Designer carry out a kick-off meeting to define our approach, methods, applicable rules and technical documentation to be provided

c) The Flag Administration is to be involved to share the project program and the relevant defined assessment procedure

d) Perform the technical assessment (approval of the project and verification on board)

e) Delivery of the technical documentation

3 Process and Verification Documentation

3.1 General

3.1.1 Considering the different types of design solutions different process/documentation for the verification may be adopted. It is to be carried out by The Society the examination according to the applicable rules defined above and provide an Approval in Principle. The process may be developed for each type of installation and gas/fuel fitted on board using different process and different verification document (see Tab 1)

a) Risk Assessment (RA)

b) Failure Mode Effect Analysis (FMEA)

c) Hazard Identification (HAZID)

d) Hazard Operation (HAZOP)

e) Type Approval (TA)

Table 1 : Verification Process

	CLASS reference		PROCESS				
	Part C (1)	Approval in Principle	Risk Assesment	FMEA	HAZID	HAZOP	TA
GAS FUELLED	X	X	X				
LPG OR NH_3 FUELLED	X	X	X	X	X	X	
HYDROGEN FUELLED	X	X	X	X	X	X	
METHANOL/ETHANOL	X	X	X	X	X	X	
FUEL CELLS POWERD	X	X					X
BATTERY POWERED	X	X					X
BIOFUEL	X	X	X (2)				

Notes:
1) Rules of the Classification of Ships or Yachts according to [1.2.1].
2) When required in Pt C, Ch 1, App 16 of Tasneef Rules of the Classification of Ships

4 Alternative arrangements

4.1 General

4.1.1 For each fuel alternative solutions may be acceptable granting an equivalent level of safety based on a risk analysis.

SECTION 5 PRESSURE VESSELS

1 General

1.1 Principles

1.1.1 Scope of the Rules

The pressure vessels, associated piping systems and fittings shall be of a design and construction adequate for the service for which they are intended and shall be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards. The design is to have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

1.1.2 Continuity of service

The Society shall give special consideration to the reliability of single essential propulsion components and may require a separate source of propulsion power sufficient to give the yacht a navigable speed, especially in the case of unconventional arrangements.

1.1.3 Tests

All pressure vessels including their associated fittings which are under internal pressure shall be subjected to appropriate tests including a pressure test before being put into service for the first time (see also [7]).

1.1.4 Protection against overpressure

Where main or auxiliary boilers and other pressure vessels or any parts thereof may be subject to dangerous overpressure, means shall be provided where practicable to protect against such excessive pressure.

1.2 Application

1.2.1 Pressure vessels covered by the Rules

The requirements of this Section apply to pressure vessels of metallic construction and heat exchangers, including the associated fittings and mountings with the exception of those indicated in [1.2.2].

1.2.2 Boilers and pressure vessels not covered by the Rules

This Section is not applicable to pressure vessels of class 3, having design pressure p <= 1 MPa and product p V <= 150 (V being the internal volume, in dm3, calculated deducting the volume of tube bundles, if any).

However, Tasneef reserves the right to apply all or part of the requirements of this Section to class 3 heat exchangers and pressure vessels, depending on the criticality of the equipment and/or of the system of which they are part.

The requirements of this Section are not applicable to pressure vessels that are part of non essential systems and whatever the working pressure of the vessel if they are fitted in a protected location where a failure will not constitute danger to passengers or crew and will not produce failure to essential systems.

Small pressure vessels included in self-contained domestic equipment are not covered by the Rules and will be considered on a case by case basis.

1.2.3 Pressure vessels not requiring design approval

Plan approval is not required for pressure vessels of class 3 (as specified in [1.4]), having design pressure p < 1 MPa and product p V <= 150 (V being the internal volume, in dm^3, calculated deducting the volume of tube bundles, if any).

However, the Society reserves the right to apply all or part of the requirements of this Section to class 3 heat exchangers and pressure vessels, depending on the criticality of the equipment and/or of the system of which they are part.

1.3 Definitions

1.3.1 Pressure vessel

Pressure vessel is a welded or seamless container used for the containment of fluids at a pressure above or below the ambient pressure and at any temperature. Fluid power cylinders in hydraulic or pneumatic plants are also considered pressure vessels.

1.3.2 Heat exchanger

Heat exchanger is a pressure vessel used to heat or cool a fluid with another fluid. In general heat exchangers are composed of a number of adjacent chambers, the two fluids flowing separately in adjacent chambers. One or more chambers may consist of bundles of tubes.

1.3.3 Incinerator *(1/1/2025)*

Incinerator is a board facility for incinerating solid garbage approximating in composition to household garbage and liquid garbage deriving from the operation of the (e.g. domestic garbage, maintenance garbage, operational garbage), as well as for burning sludge with a flash point above 60°C.

These facilities may be designed to use the heat energy produced.

1.3.4 Design pressure

The design pressure is the pressure used by the manufacturer to determine the scantlings of the vessel. This pressure cannot be taken less than the maximum working pressure and is to be limited by the set pressure of the safety valve, as prescribed by the applicable Rules.

1.3.5 Design temperature

a) Design temperature is the actual metal temperature of the applicable part under the expected operating conditions. This temperature is to be stated by the manufacturer and is to take account of the effect of any temperature fluctuations which may occur during the service.

b) The design temperature is to be not less than the maximum temperature of the internal fluid unless specially agreed between the manufacturer and the Society on a case by case basis.

1.3.6 Ductile material

For the purpose of this Section, ductile material is a material having an elongation over 12%.

Table 1 : Pressure vessels classification

Equipment	class 1	class 2	class 3
Pressure vessels and heat exchangers	$p > 4$ MPa, or $t_A > 40$ mm, or $T > 350$°C	$1,75 < p \leq 4$ MPa, or $15 < t_A \leq 40$ mm, or $150 < T \leq 350$°C, or $p.t_A > 15$	All pressure vessels and heat exchangers which are not class 1 or 2
Note 1: Whenever the class is defined by more than one characteristic, the equipment is to be considered belonging to the highest class of its characteristics, independently of the values of the other characteristics.			

1.4 Classes

1.4.1 Pressure vessels are classed as indicated in Tab 1 in consideration of their service, characteristics and scantlings. The symbols used in the table have the following meanings:

p : Design pressure, in MPa

T : Design temperature, in °C

D : Inside diameter of the vessel, in mm

t_A : Actual thickness of the vessel, in mm

1.5 Alternative standards

1.5.1

a) Pressure vessels are to be designed, constructed, installed and tested in accordance with the applicable requirements of this Section.

b) The acceptance of national and international standards as an alternative to the requirements of this Section may be considered by the Society on a case by case basis.

1.6 Documentation to be submitted

1.6.1 Pressure vessels and heat exchangers

The plans listed in Tab 2 are to be submitted.

The drawings listed in Tab 2 are to contain at least the constructional details of all pressure parts, such as shells, headers, tubes, tube plates, nozzles, opening reinforcements and covers, and of all strengthening members, such as stays, brackets and reinforcements.

Table 2 : Drawings, information and data to be submitted for pressure vessels and heat exchangers

No.	A/I	Item
1	I	General arrangement plan including nozzles and fittings
2	A	Sectional assembly
3	A	Material specifications
4	A	Welding details, including at least: • Typical weld joint design • Welding procedure specifications • Post-weld heat treatments
5	I	Design data, including at least design pressure and design temperatures (as applicable)
6	A	For seamless (extruded) pressure vessels, the manufacturing process including: • A description of the manufacturing process with indication of the production controls normally carried out in the manufacturer's works • Details of the materials to be used (specification, yield point, tensile strength, impact strength, heat treatment) • Details of the stamped marking to be applied
7	I	Type of fluid or fluids contained
Note 1: A = to be submitted for approval I = to be submitted for information		

1.6.2 Incinerators

Incinerators will be considered on a case by case basis, based on their actual arrangement, using the applicable requirements for boilers and pressure vessels.

2 Design and Construction - Principles

2.1 Materials

2.1.1 Materials for high temperatures

a) Materials for pressure parts having a design temperature exceeding the ambient temperature are to have mechanical and metallurgical properties adequate for the design temperature. Their allowable stress limits are to be determined as a function of the temperature, as per [3.2].

b) When the design temperature of pressure parts exceeds 400°C, alloy steels are to be used. Other materials are subject of special consideration by the Society.

2.1.2 Materials for low temperatures

Materials for pressure parts having a design temperature below the ambient temperature are to have notch toughness properties suitable for the design temperature.

2.1.3 Cast iron

Grey cast iron is not to be used for:

a) class 1 and class 2 pressure vessels

b) class 3 pressure vessels with design pressure p > 0,7MPa or product pV > 15, where V is the internal volume of the pressure vessel in m^3

c) Bolted covers and closures of pressure vessels having a design pressure p > 1MPa, except for covers intended for boiler shells, for which [2.2.3] applies.

Spheroidal cast iron may be used subect to the agreement of the Society following special consideration. However, it is not to be used for parts having a design temperature exceeding 350°C.

2.1.4 Alternative materials

In the case of boilers or pressure vessels constructed in accordance with one of the standards considered acceptable by the Society as per [1.5], the material specifications are to be in compliance with the requirements of the standard used.

2.2 Pressure vessels

2.2.1 Access arrangement

a) Pressure vessels are to be provided with openings in sufficient number and size to permit internal examination, cleaning and maintenance operations. In general, all pressure vessels which are part of a boiler with inside diameter exceeding 1200 mm, and those with inside diameter exceeding 800 mm and length exceeding 2000 mm, are to be provided with access manholes.

b) Manholes are to be provided in suitable locations in the shells, headers, domes, and steam and water drums, as applicable. The “net” (actual hole) dimension of elliptical or similar manholes is to be not less than 300 mm x 400 mm. The “net” diameter of circular manholes (actual hole) cannot be less than 400 mm. The edges of manholes are to be adequately strengthened to provide compensation for vessel openings in accordance with [3.3.10] and [3.4.8], as applicable.

c) In pressure vessels which are part of a boiler and are not covered by the requirement in a) above, or where an access manhole cannot be fitted, at least the following openings are to be provided, as far as practicable:
   - Head holes: minimum dimensions: 220mm x 320mm (320 mm diameter if circular)
   - Handholes: minimum dimensions: 87mm x 103mm
   - Sight holes: minimum diameter: 50 mm.

d) Sight holes may only be provided when the arrangement of manholes, head holes, or handholes is impracticable.

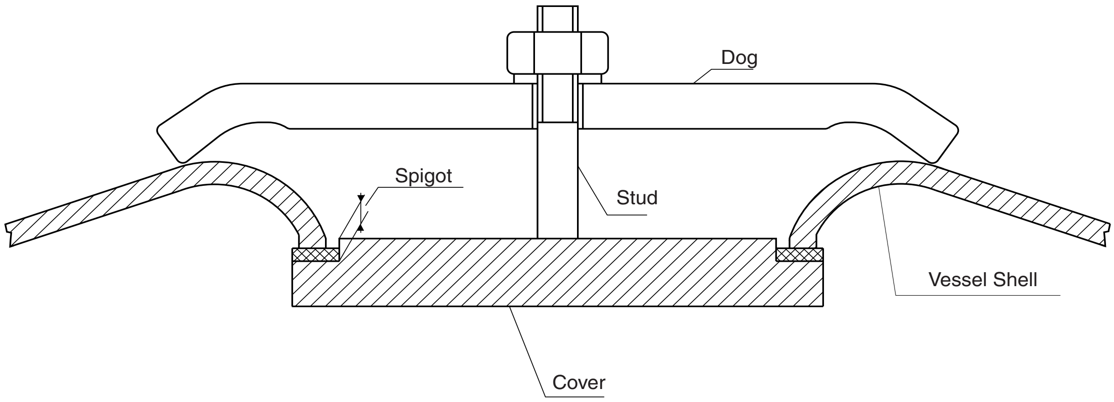
e) Covers for manholes and other openings are to be made of ductile steel, dished or welded steel plates or other approved design. Grey cast iron may be used only for small openings, such as handholes and sight holes, provided the design pressure p does not exceed 1 MPa and the design temperature T does not exceed 220°C.

f) Covers of the internal type are to have a spigot passing through the opening. The clearance between the spigot and the edge of the opening is to be uniform for the whole periphery of the opening and is not to exceed 1,5 mm. Fig 1 shows a typical arrangement.

g) Closing devices of internal type covers, having dimensions not exceeding 180mm x 230mm, may be fitted with a single fastening bolt or stud. Larger closing devices are to be fitted with at least two bolts or studs. For fastening bolt or stud arrangement see Fig 1.

h) Covers are to be designed so as to prevent the dislocation of the required gasket by the internal pressure. Only continuous ring gaskets may be used for packing.

Figure 1 : Opening cover



2.2.2 Safety valves

a) Pressure vessels which are part of a system are to be provided with safety valves, or equivalent devices, if they are liable to be isolated from the system safety devices. This provision is also to be made in all cases in which the vessel pressure can rise, for any reason, above the design pressure. See also [6.3] for grouped pressure vessels.

b) In particular, air pressure vessels which can be isolated from the safety valves ensuring their protection in normal service are to be fitted with another safety device, such as a rupture disc or a fusible plug, in order to ensure their discharge in case of fire. This device is to discharge to the open.

c) Safety devices ensuring protection of pressure vessels in normal service are to be rated to operate before the pressure exceeds the maximum working pressure by more than 5%.

2.2.3 Protection of heat exchangers

Special attention is to be paid to the protection against overpressure of vessels, such as heat exchangers, which have parts that are designed for a pressure which is below that to which they might be subjected in the case of rupture of the tubular bundles or coils contained therein and that have been designed for a higher pressure.

2.2.4 Corrosion protection

Vessels and equipment containing media that might lead to accelerated corrosion are to be suitably protected.

2.2.5 Drainage

a) Each air pressure vessel is to be fitted with a drainage device allowing the evacuation of any oil or water accumulated in the vessel.

b) Drainage devices are also to be fitted on other vessels, in particular steam vessels, in which condensation water is likely to accumulate.

2.2.6 Marking

a) Each pressure vessel is to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of manufacturer, year and serial number):
   - the design pressure
   - the design temperature
   - the test pressure and the date of the test

b) Markings may be directly stamped on the vessel if this does not produce notches having an adverse influence on its behaviour in service.

c) For smaller pressure vessels the indication of the design pressure only may be sufficient.

2.3 Special types of pressure vessels

2.3.1 Seamless pressure vessels (bottles)

Each bottle is to be marked with the following information:

- Name or trade name of the manufacturer
- Serial number
- Type of gas

- Capacity
- Test pressure
- Empty weight
- Test stamp.

3 Design and construction - Scantlings

3.1 General

3.1.1 Application

a) In general, the formulae in this Section do not take into account additional stresses imposed by effects other than pressure, such as stresses deriving from the static and dynamic weight of the vessel and its content, external loads from connecting equipment and foundations, etc. For the purpose of the Rules these additional loads may be neglected, provided it can reasonably be presumed that the actual average stresses of the vessel, considering all these additional loads, would not increase more than 10% with respect to the stresses calculated by the formulae in this Section.

b) Where it is necessary to take into account additional stresses, such as dynamic loads, the Society reserves the right to ask for additional requirements on a case by case basis.

3.1.2 Additional requirements

When pressure parts are of an irregular shape, such as to make it impossible to check the scantlings by applying the formulae of this Section, the approval is to be based on other means, such as burst and/or deformation tests on a prototype or by another method agreed upon between the manufacturer and the Society.

3.2 Permissible stresses

3.2.1 Permissible stress tables

The permissible stresses K, in N/mm², for steels, to be used in the formulae of this Section, may be determined from Tab 3 and Tab 4, where R_m is the ultimate strength of the material in N/mm². For intermediate values of the temperature, the value of K is to be obtained by linear interpolation.

Table 3 : Permissible stresses K for carbon steels intended for other pressure vessels

Carbon steel	T (°C)	≤ 50	100	150	200	250	300	350	400
R_m = 360 N/mm² Grade HA	t ≤ 15 mm	133	117	115	112	100	83	78	77
	15 mm < t ≤ 40 mm	133	114	113	108	96	83	78	77
	40 mm < t ≤ 60 mm	130	108	105	101	94	83	78	77
R_m = 360 N/mm² Grades HB, HD	t ≤ 15 mm	133	133	123	110	97	85	77	73
	15 mm < t ≤ 40 mm	133	131	122	109	97	85	77	73
	40 mm < t ≤ 60 mm	133	119	115	106	97	85	77	73
R_m = 410 N/mm² Grade HA	t ≤ 15 mm	152	141	139	134	120	100	95	92
	15 mm < t ≤40 mm	152	134	132	127	114	100	95	92
	40 mm < t ≤ 60 mm	150	128	121	112	112	100	95	92
R_m = 410 N/mm² Grades HB, HD	t ≤ 15 mm	152	152	144	129	114	101	94	89
	15 mm < t ≤ 40 mm	152	152	142	128	114	101	94	89
	40 mm < t ≤ 60 mm	152	143	139	125	114	101	94	89
R_m = 460 N/mm² Grades HB, HD	t ≤ 15 mm	170	170	165	149	132	118	111	105
	15 mm < t ≤ 40 mm	170	170	161	147	132	118	111	105
	40 mm < t ≤ 60 mm	170	167	157	145	132	118	111	105
R_m = 510 N/mm² Grades HB, HD	t ≤ 60 mm	189	189	180	170	157	143	133	120

Table 4 : Permissible stresses K for alloy steels intended for other pressure vessels

Alloy steel	T(°C)	≤ 50	100	150	200	250	300	350	400	450	475	500	525	550	575	600
0,3Mo	t ≤ 60 mm	159	159	153	143	133	113	107	100	97	95	93	38			
1Cr 0,5Mo	t ≤ 60 mm	167	167	167	154	146	137	127	119	113	111	110	59	33	20	
2,25Cr 1Mo **(1)**	t ≤ 60 mm	183	174	167	157	154	146	140	133	127	123	119	65	44	32	23
2,25Cr 1Mo **(2)**	t ≤ 60 mm	174	174	174	172	170	157	150	139	137	133	130	65	44	32	23

(1) Normalised and tempered
(2) Normalised and tempered or quenched and tempered

3.2.2 Direct determination of permissible stresses

The permissible stresses K, where not otherwise specified, may be taken as indicated below.

a) Steel:

The permissible stress is to be the minimum of the values obtained by the following formulae:

$$K = \frac{R_{m,20}}{2,7}$$

$$K = \frac{R_{S,MIN,T}}{A}$$

$$K = \frac{S_A}{A}$$

where:

$R_{m,20}$: Minimum tensile strength at ambient temperature (20°C), in N/mm^2

$R_{S,MIN,T}$: Minimum between R_{eH} and $R_{p\,0,2}$ at the design temperature T, in N/mm^2

S_A : Average stress to produce creep rupture in 100000 hours, in N/mm^2, at the design temperature T

A : Safety factor taken as follows, when reliability of $R_{S,MIN,T}$ and S_A values are proved to the Society's satisfaction:

- 1,5 for other pressure vessels
- specially considered by the Society if average stress to produce creep rupture in more than 100000 hours is used instead of S_A

In the case of steel castings, the permissible stress K, calculated as above, is to be decreased by 20%. Where steel castings are subjected to non-destructive tests, a smaller reduction up to 10% may be taken into consideration by the Society.

b) Spheroidal cast iron:

The permissible stress is be to the minimum of the values obtained by the following formulae:

$$K = \frac{R_{m,20}}{4,8}$$

$$K = \frac{R_{S,MIN,T}}{3}$$

c) Grey cast iron:

The permissible stress is obtained by the following formula:

$$K = \frac{R_{m,20}}{10}$$

d) Copper alloys:

The permissible stress is obtained by the following formula:

$$K = \frac{R_{m,T}}{4}$$

where:

$R_{m,T}$: Minimum tensile strength at the design temperature T, in N/mm^2

e) Aluminium and aluminium alloys:

The permissible stress is to be the minimum of the values obtained by the following formulae:

$$K = \frac{R_{m,T}}{4}$$

$$K = \frac{R_{e,H}}{1,5}$$

where:

$R_{e,H}$: Minimum yield stress, in N/mm^2

f) Additional conditions:

- In special cases the Society reserves the right to apply values of permissible stress K lower than those specified above.
- For materials other than those listed above the permissible stress is to be agreed with the Society on a case by case basis.

3.3 Cylindrical, spherical and conical shells with circular cross-sections subject to internal pressure

3.3.1 Cylindrical shell thickness

a) The minimum thickness of cylindrical, spherical and conical shells with circular cross-sections is not to be less than the value t, in mm, calculated by one of the following formulae, as appropriate. Cylindrical tube plates pierced by a great number of tube holes are to have thickness calculated by the applicable formula in [3.3.2], [3.3.3], [3.3.4] and [3.7.2].

b) The thicknesses obtained by the formulae in [3.3.2], [3.3.3], [3.3.4], are “net” thicknesses, as they do not include any corrosion allowance. Unless a greater value is agreed in the vessel contract specification, the thickness obtained by the above formulae is to be increased by 0.75 mm. See also [3.3.7].

3.3.2 Cylindrical shells

a) When the ratio external diameter/inside diameter is equal to or less than 1,5, the minimum thickness of cylindrical shells is given by the following formula:

$$t = \frac{pD}{2Ke - p}$$

where:

p : Design pressure, in MPa

D : Inside diameter of vessel, in mm

K : Permissible stress, in N/mm^2, obtained as specified in [3.2]

e : Efficiency of welded joint. For the value of the efficiency e, see [3.3.5].

b) The minimum thickness of shells having ratio external diameter/inside diameter exceeding 1,5 is subject of special consideration.

3.3.3 Spherical shells

a) When the ratio external diameter/inside diameter is equal to or less than 1,5, the minimum thickness of spherical shells is given by the following formula:

$$t = \frac{pD}{4Ke - p}$$

For the meaning of the symbols, see [3.3.2].

b) The minimum thickness of shells having ratio external diameter/inside diameter exceeding 1,5 is subject of special consideration.

3.3.4 Conical shells

a) The following formula applies to conical shells of thickness not exceeding 1/6 of the external diameter in way of the large end of the cone.

$$t = \frac{pD}{(2Ke - p) \cdot \cos\varphi}$$

For the meaning of the symbols, see [3.3.2].

D is measured in way of the large end of the cone and φ is the angle of slope of the conical section of the shell to the pressure vessel axis (see Fig 2). When φ exceeds 75°, the shell thickness is to be taken as required for flat heads, see [3.5].

b) The minimum thickness of shells having thickness exceeding 1/6 of the external diameter in way of the large end of the cone is subject of special consideration.

c) Conical shells may be made of several ring sections of decreasing thickness. The minimum thickness of each section is to be obtained by the formula in a) using for D the maximum diameter of the considered section.

d) In general, the junction with a sharp angle between the conical shell and the cylindrical or other conical shell, having different angle of slope, is not allowed if the angle of the generating line of the shells to be assembled exceeds 30°.

e) The shell thickness in way of knuckles is subject of special consideration by the Society.

3.3.5 Efficiency

The values of efficiency e to be used in the formulae in [3.3.2], [3.3.3] and [3.3.4] are indicated in Tab 5.

Table 5 : Efficiency of unpierced shells

Case	e
Seamless shells	1
Shells of class 1 vessels **(1)**	1
Shells of class 2 vessels (with partial radiographic examination of butt-joints)	0,85
Shells of class 2 vessels (without radiographic examination of butt-joints)	0,75
Shells of class 3 vessels	0,6
(1) In special cases the Society reserves the right to take a factor e < 1, depending on the welding procedure adopted for the welded joint.	

3.3.6 Minimum thickness

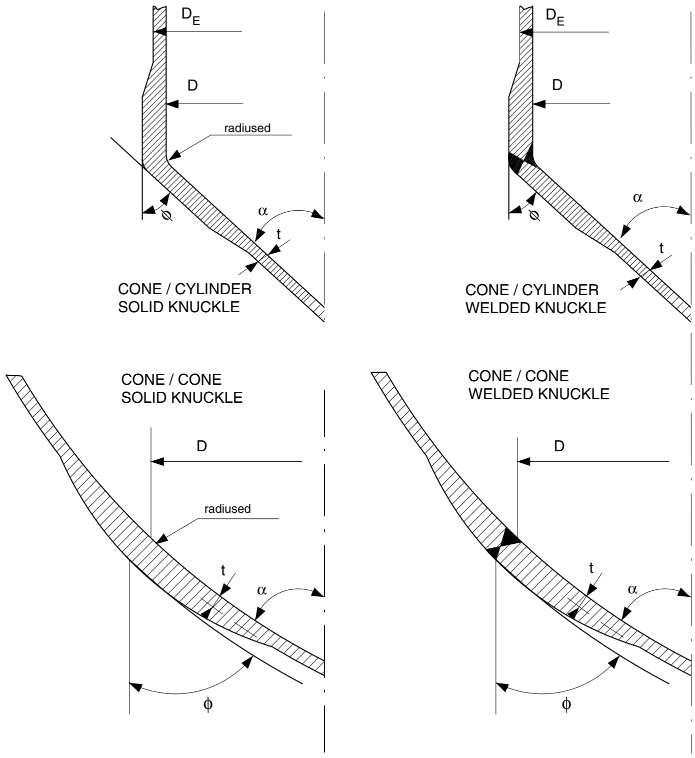
Irrespective of the value calculated by the formulae in [3.3.2], [3.3.3] [3.3.4], the thickness t of shells is to be not less than one of the following values, as applicable

- for pressure vessels:
  - in carbon and low alloy steel: t = 3 + D/1500 mm
  - in stainless steel and non-ferrous materials: t = 3 mm

No corrosion allowance needs to be added to the above values.

For pressure vessels where the cylindrical part is made of a pipe or where corrosion-resistant materials are used, a smaller minimum thickness may be accepted.

Figure 2 : Conic shells



3.3.7 Corrosion allowance

The Society reserves the right to increase the corrosion allowance value in the case of vessels exposed to particular accelerating corrosion conditions. The Society may also consider the reduction of this factor where particular measures are taken to effectively reduce the corrosion rate of the vessel.

3.3.8 Openings in shells

a) In general, the largest dimensions of the openings in shells are not to exceed:
   - for shells up to 1500 mm in diameter D_E: 1/2 D_E, but not more than 500 mm
   - for shells over 1500 mm in diameter D_E: 1/3 D_E, but not more than 1000 mm

   where D_E is the vessel external diameter, in mm.

   Greater values may be considered by the Society on a case by case basis.

b) In general, in oval or elliptical openings the ratio major diameter/minor diameter is not to exceed 2.

c) Openings are considered isolated when the distance between the centres of two adjacent holes in the longitudinal axis is not less than:

   $d + 1{,}1(D \cdot t_A)^{0,5}$ or

   5 d

   whichever is the lesser,

   where:

   d : Diameter of the openings, in mm, (if the two openings have different diameter, d is the average diameter).

3.3.9 Openings requiring compensation

The following openings are to be compensated in accordance with the requirements of [3.3.10]:

a) Isolated openings in shell plates having a diameter, in mm, greater than the smaller of the following values:

   2,5 t + 70 or

   $\frac{D}{6}$ or

   200 mm

   whichever is the lesser, where t is the thickness calculated by the formulae in [3.3.2], [3.3.3] or [3.3.4] as applicable, using an efficiency value e equal to 1 and not adding the corrosion constant.

b) Non-isolated openings.

3.3.10 Compensation of openings in shells

a) The compensation area is to be provided in each diametrical direction of the opening and is to be at least equal to the area of the missing material in that direction, corrected as indicated in b).

The area of the missing material in one direction is the width of the opening in that direction multiplied by the required minimum shell thickness calculated by the formulae in [3.3.2], [3.3.3], or [3.3.4], as applicable, using an efficiency value e equal to 1 without corrosion constant.

b) The area corresponding to the maximum opening diameter for which compensation is not required may be deducted from the computation of the compensating area to be provided.

c) Material around the opening outside the width exceeding the opening radius in any direction is not to be included in the calculation of the compensation.

d) Excess thickness in the shell with respect to the Rule thickness t, calculated as indicated in a), may be considered as contributing to the compensation of the opening for a width not exceeding the opening radius.

e) Where nozzles are welded to the shell, their excess thickness with respect to the Rule thickness, calculated in accordance with the requirements in [3.6.1], may be considered as contributing to the compensation of the hole for a height h, in mm, equal to:

$$h = [(d_B - 2t_B) \cdot t_B]^{0,5}$$

where d_B and t_B are the values, in mm, of the outer diameter and thickness of the nozzle, respectively. See also Fig 3.

f) The sectional area of welds connecting compensating parts may be included in the compensation calculation if they fall inside the area mentioned in a).

g) If the material of rings, nozzles and reinforcement collars has a lower permissible stress than the shell material, the compensating area is to be proportionally increased.

h) Fig 3 summarises the compensation criteria described in the above items.

i) Different arrangements will be specially considered by the Society on a case by case basis.

3.3.11 Cylindrical shells pierced by tube holes

For the minimum thickness of cylindrical shells pierced by tube holes, see [3.7.1].

3.3.12 Covers

a) Circular, oval and elliptical inspection openings are to be provided with steel covers. Inspection openings on boilers with a diameter not exceeding 150 mm and on pressure vessels may be closed by blind flanges.

b) The thickness of the opening covers is not to be less than the value t, in mm, given by the following formula:

$$t = 1,22 \cdot a \cdot \left(\frac{pC}{K}\right)^{0,5}$$

where:

a : The minor axis of the oval or elliptical opening, measured at half width of gasket, in mm

b : The major axis of the oval or elliptical opening, measured at half width of the gasket, in mm

C : Coefficient in Tab 6 as a function of the ratio b/a of the axes of the oval or elliptical opening, as defined above. For intermediate values of the ratio b/a, the value of C is to be obtained by linear interpolation.

For circular openings the diameter d, in mm, is to be used in the above formula instead of a.

c) The thickness obtained by the formula in a) is “net” thickness, as it does not include any corrosion allowance. Unless a greater value is agreed in the vessel contract specification, the thickness obtained by the above formula is to be increased by 1 mm. See also [3.3.7]

d) The formula in b) above is calibrated for flat covers.

e) For concave covers, also scantlings based on the formula for concave heads in [3.4.3] may be accepted to the satisfaction of the Society.

f) The provisions of this paragraph also apply to covers located on the dished heads.

Figure 3 : Opening compensation

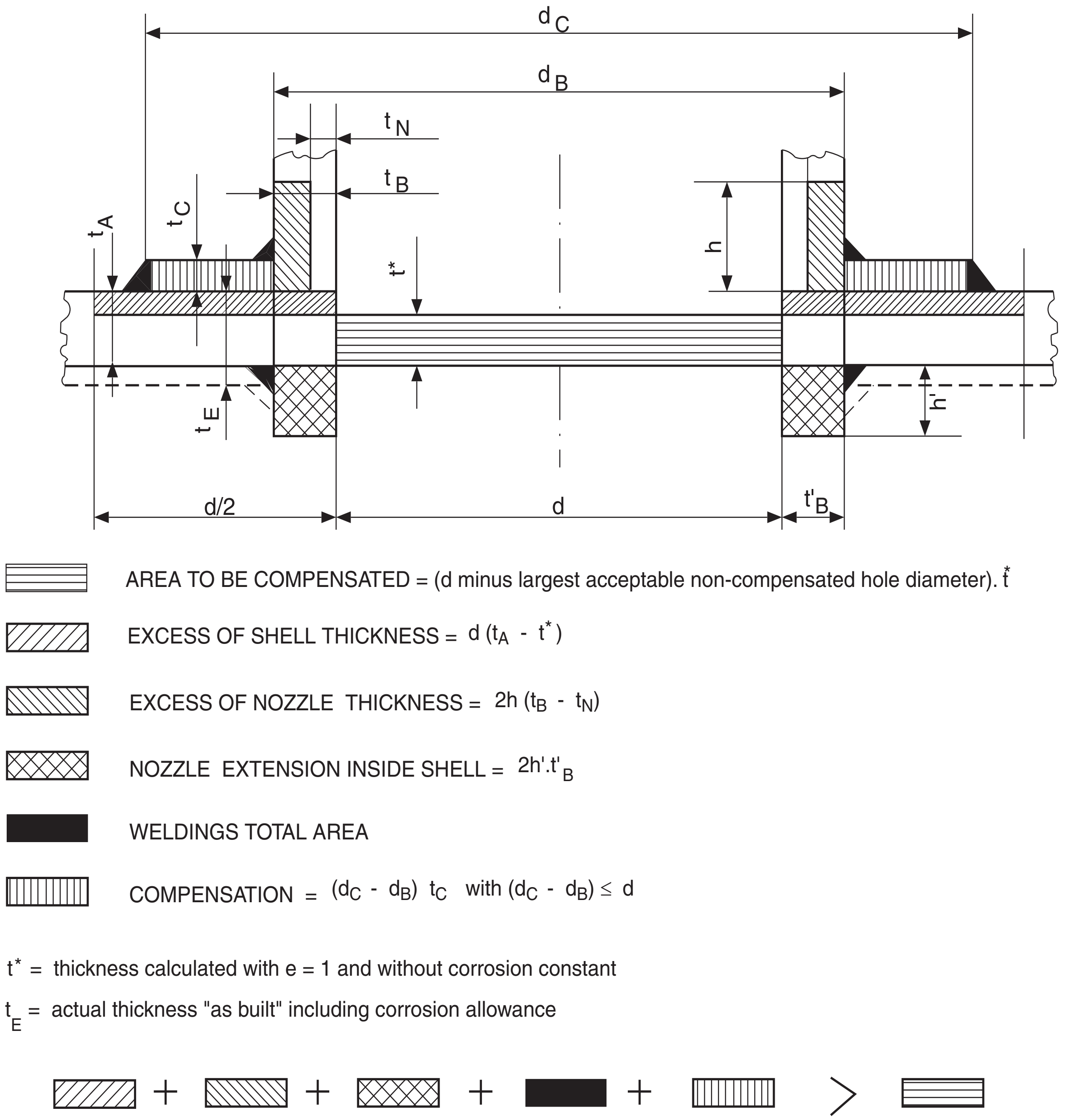


Table 6 : Coefficient C

b/a	1,00	1,05	1,10	1,15	1,20	1,25	1,30	1,40	1,50	1,60
C	0,206	0,220	0,235	0,247	0,259	0,271	0,282	0,302	0,321	0,333

b/a	1,70	1,80	1,90	2,00	2,50	3,00	3,50	4,00	4,50	5,00
C	0,344	0,356	0,368	0,379	0,406	0,433	0,449	0,465	0,473	0,480

3.4 Dished heads subject to pressure on the concave (internal) side

3.4.1 Dished head profile

The following requirements are to be complied with for the determination of the profile of dished heads (see Fig 4 (a) and (b)).

a) Ellipsoidal heads:

$H \geq 0,2\ D$

where:

H : External depth of head, in mm, measured from the start of curvature at the base.

D : Outside diameter of the head base, in mm

b) Torispherical heads:

$R_{IN} \leq D$

$r_{IN} \geq 0,1\ D$

$r_{IN} \geq 3\ t$

$H \geq 0,18\ D$

where:

R_{IN} : Internal radius of the spherical part, in mm

r_{IN} : Internal knuckle radius, in mm

D : Outside diameter of the head base, in mm

H : External depth of head calculated by the following formula (see Fig 4 (b)):

$H = R_E - [(R_E - 0,5\ D).(R_E + 0,5\ D - 2\ r_E)]^{0,5}$

where:

R_E : External radius of the spherical part, in mm

r_E : External knuckle radius, in mm.

3.4.2 Required thickness of solid dished heads

a) The minimum thickness of solid (not pierced) hemispherical, torispherical, or ellipsoidal unstayed dished heads, subject to pressure on the concave (internal) side, is to be not less than the value t, in mm, calculated by the following formula:

$$t = \frac{pDC}{2Ke}$$

where:

C : Shape factor, obtained from the graph in Fig 5, as a function of H/D and t/D

for other symbols, see [3.3.2].

b) The thickness obtained by the formula in a) is "net" thickness, as it does not include any corrosion allowance. Unless a greater value is agreed in the vessel contract specification, the thickness obtained by the above formula is to be increased by 0.75 mm. See also [3.3.7].

3.4.3 Composed torispherical heads

a) Torispherical heads may be constructed with welded elements of different thickness (see Fig 6).

b) Where a torispherical head is built in two sections, the thickness of the torispherical part is to be obtained by the formula in [3.4.3], while the thickness of the spherical part may be obtained by the formula in [3.3.3].

c) The spherical part may commence at a distance from the knuckle not less than:

$0,5.(R_{IN}.t)^{0,5}$

where:

R_{IN} : Internal radius of the spherical part, in mm

t : Knuckle thickness, in mm

3.4.4 Minimum thickness

Irrespective of the value calculated in [3.4.3] and [3.4.4] the thickness t of dished heads is not to be less than:

- 3 + D/1500 mm for normal pressure vessels in carbon and low alloy steel
- 3 mm for normal pressure vessels in stainless steel and non-ferrous materials

No corrosion allowance needs to be added to the above values.

3.4.5 Connection of heads to cylindrical shells

The heads are to be provided, at their base, with a cylindrical skirt not less than 2t in length and with a thickness in no case less than the Rule thickness of a cylindrical shell of the same diameter and the same material, calculated by the formula given in [3.3.2] using the same efficiency factor e adopted for calculation of the head thickness. Fig 7 and Fig 8 show typical admissible attachments of dished ends to cylindrical shells.

In particular, hemispherical heads not provided with the above skirt are to be connected to the cylindrical shell if the latter is thicker than the head, as shown in Fig 8.

Other types of connections are subject of special consideration by the Society.

Figure 4 : Dished head profiles

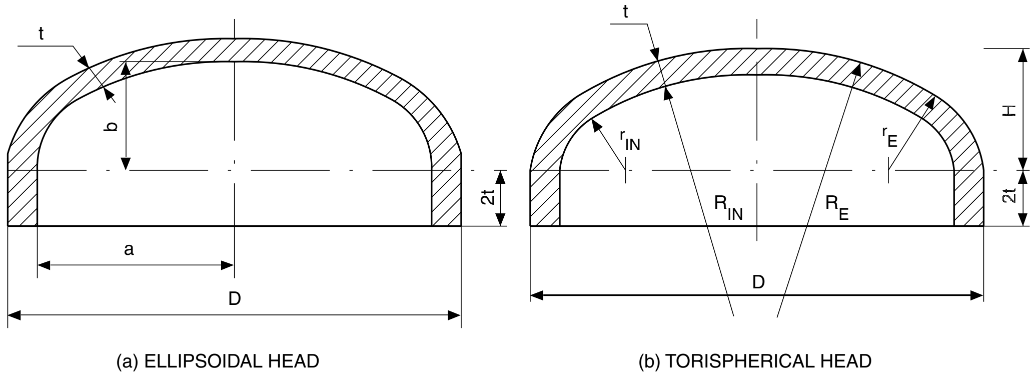


Figure 5 : Shape factor for dished heads

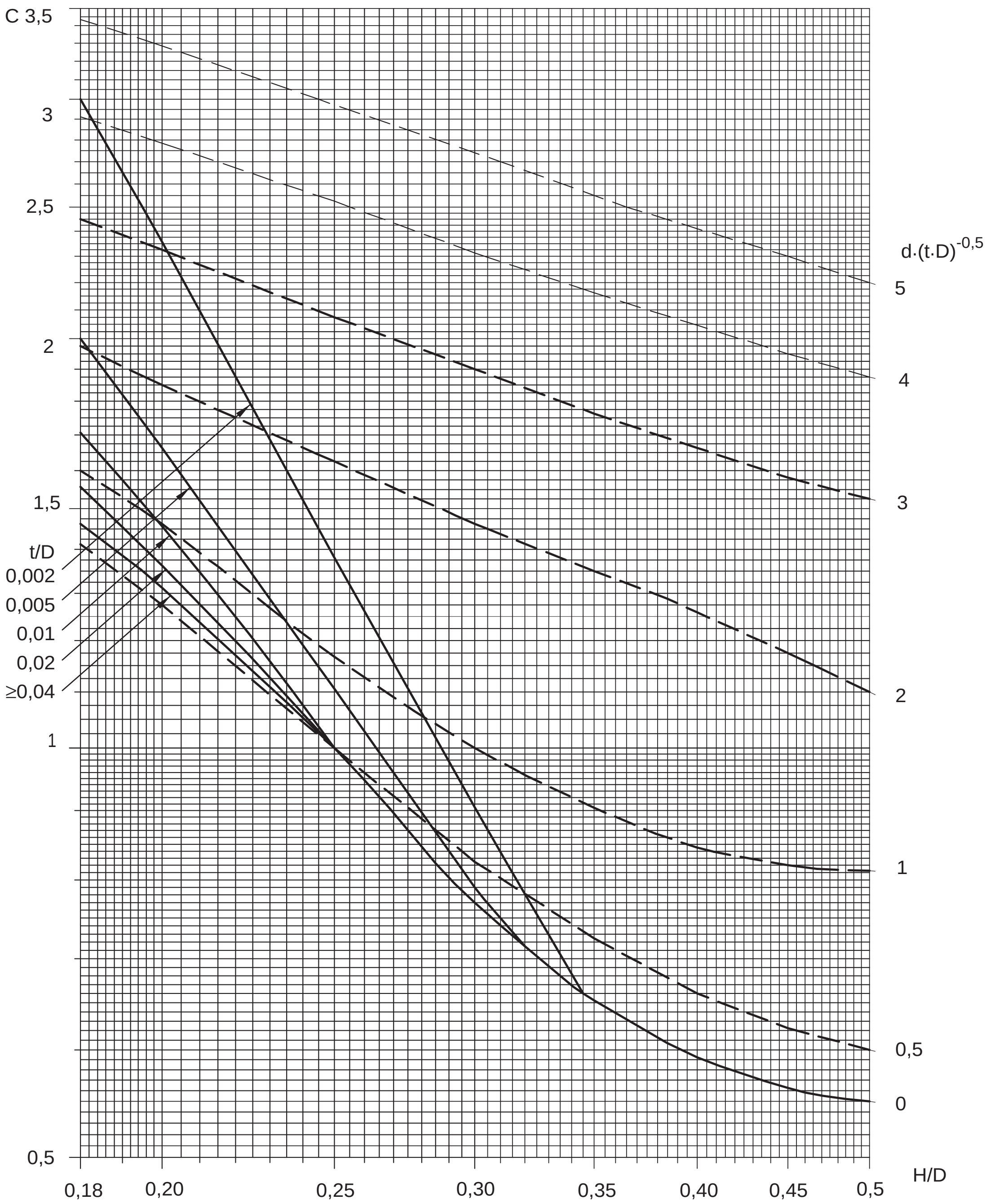
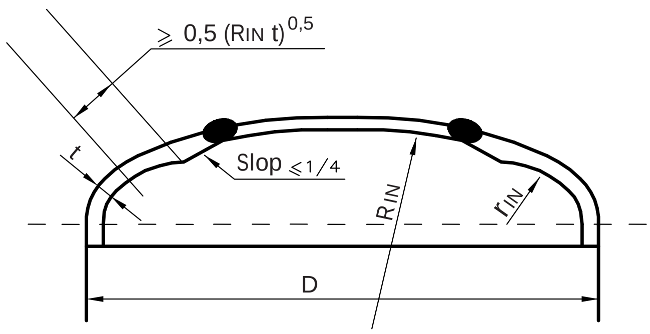


Figure 6 : Composed torispherical head



3.4.6 Dished heads with openings

a) The openings in dished heads may be circular, elliptical or oval.

b) The largest diameter of the non-compensated opening is not to exceed one half of the external diameter of the head.

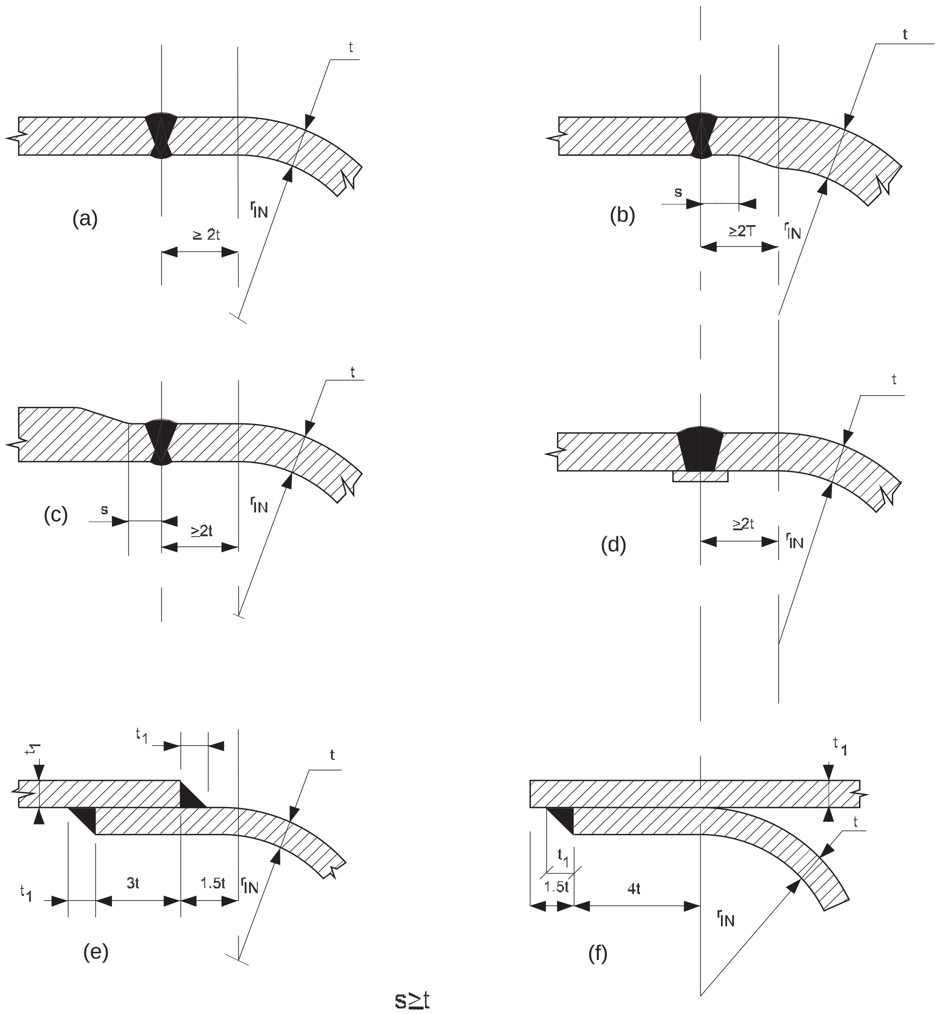
c) The opening is to be so situated that its projection, or its reinforcement projection in the case of compensated openings, is completely contained inside a circle having its centre at the centre of the head and a diameter of 0,8D, D being the external diameter of the head (see Fig 9). However, a small reinforced opening for drainage may be accepted outside the indicated area.

d) In the case of non-compensated openings (for this purpose, flanged openings are also to be considered as non-compensated), the head thickness is not to be less than that calculated by the formula in [3.4.3] using the smallest of the shape factors C obtained from the graph in Fig 5 as a function of:

H/D and t/D or H/D and $d.(t.D)^{-0,5}$,

where d is the diameter of the largest non-compensated opening in the head, in mm. For oval and elliptical openings, d is the width of the opening in way of its major axis.

Figure 7 : Typical attachment of dished heads to cylindrical shells



Types shown in (a), (b) and (c) are acceptable for all pressure vessels.

Type shown in (d) is acceptable for class 2 and class 3 pressure vessels.

Types shown in (e) and (f) are acceptable for class 3 pressure vessels only.

e) In all cases the diameter D of the head base, the head thickness t and the diameter d of the largest non-compensated opening are to be such as to meet the following requirements:

- The position of non-compensated openings in the heads is to be as shown in Fig 9
- For flanged openings, the radius r of the flanging (see Fig 9) is not to be less than 25 mm
- The thickness of the flanged part may be less than the Rule thickness.

3.4.7 Compensated openings in dished heads

a) Where openings are cut in dished heads and the proposed thickness of the head is less than that calculated by the formula in [3.4.3], the openings are to be compensated.

b) Fig 18, Fig 19, Fig 20 and Fig 21 show typical connections of nozzles and compensating rings.

c) The opening is considered sufficiently compensated when the head thickness t is not less than that calculated in accordance with [3.4.3] and using the shape-factor C obtained from the graph in Fig 5 using the value:

$$\left(d - \frac{A}{t}\right) \cdot (tD)^{-0,5}$$

in lieu of:

$d.(tD)^{-0,5}$

where:

A : Area, in mm^2, of the total transverse section of the compensating parts

t : Actual thickness of the head, in mm, in the zone of the opening under consideration

d) When A/t > d, the coefficient C is to be determined using the curve corresponding to the value:

$d.(tD)^{-0,5} = 0$

e) If necessary, calculations are to be repeated.

3.4.8 Compensation criteria

In the evaluation of the area A, the following is also to be taken into consideration:

a) The material that may be considered for compensating an opening is that located around the opening up to a distance l from the edge of the opening. The distance l, in mm, is the lesser obtained from the following formulae:

$l = 0,5\ d$

$l = (2\ R_{IN}\ t)^{0,5}$

where:

d : Diameter of the opening, in mm

R_{IN} : Internal radius of the spherical part, in mm, in the case of hemispherical or torispherical heads

In the case of ellipsoidal heads, R_{IN} is to be calculated by the following formula (see Fig 4 a):

$$R_{IN} = \frac{[a^4 - x^4(a^2 - b^2)]^{3/2}}{a^4 b}$$

where;

a : Half the major axis of the elliptical meridian section of the head, in mm

b : Half the minor axis of the above section, in mm

x : Distance between the centre of the hole and the rotation axis of the shell, in mm.

b) In the case of nozzles or pads welded in the hole, the section corresponding to the thickness in excess of that required is to be considered for the part which is subject to pressure and for a depth h, in mm, both on the external and internal sides of the head, not greater than:

$(d_B\ .\ t_B)^{0,5}$

where d_B and t_B are the diameter of the opening and the thickness of the pad or nozzle, in mm, respectively. See also Fig 3.

c) The area of the welding connecting nozzle and pad reinforcements may be considered as a compensating section.

d) If the material of reinforcement pads, nozzles and collars has a permissible stress lower than that of the head material, the area A, to be taken for calculation of the coefficient C, is to be reduced proportionally.

3.5 Flat heads

3.5.1 Unstayed flat head minimum thickness

a) The minimum thickness of unstayed flat heads is not to be less than the value t, in mm, calculated by the following formula:

$$t = D\left(\frac{100p}{CK}\right)^{0,5}$$

where:

p : Design pressure, in MPa

K : Permissible stress, in N/mm^2, obtained as specified in [3.2]

D : Diameter of the head, in mm. For circular section heads, the diameter D is to be measured as shown in Fig 10 and Fig 11 for various types of heads. For rectangular section heads, the equivalent value for D may be obtained from the following formula:

$$D = a\left[3{,}4 - 2{,}4\left(\frac{a}{b}\right)\right]^{0,5}$$

a and b being the smaller and larger side of the rectangle, respectively, in mm.

C : The values given below, depending on the various types of heads shown in Fig 10 and Fig 11:

Fig 10(a): C = 400 for circular heads

Fig 10(b): C = 330 for circular heads

Fig 10(c): C = 350 for circular heads

Fig 10(d): C = 400 for circular heads and C = 250 for rectangular heads

Fig 10(e): C = 350 for circular heads and C = 200 for rectangular heads

Fig 10(f): C = 350 for circular heads

Fig 10(g): C = 300 for circular heads

Fig 10(h): C = 350 for circular heads and C = 200 for rectangular heads

Fig 11(i): C = 350 for circular heads and C = 200 for rectangular heads

Fig 11(j): C = 200 for circular heads

Fig 11(k): C = 330 for circular heads

Fig 11(l): C = 300 for circular heads

Fig 11(m): C = 300 for circular heads

Fig 11(n): C = 400 for circular heads

Fig 11(o): C = value obtained from the following formula, for circular heads:

$$C = \frac{100}{0{,}3 + \frac{1{,}9Fh}{pD^3}}$$

where:

h : Radial distance, in mm, from the pitch centre diameter of bolts to the circumference of diameter D, as shown in Fig 11(o).

F : Total bolt load, in N, to be taken as the greater of the following values F_1 and F_2:

$F_1 = 0{,}785\ D\ p\ (D + m\ b)$

$F_2 = 9{,}81\ y\ D\ b$

with:

b : Effective half contact width of the gasket, in mm, calculated as follows:

$b = 0{,}5\ N$ for $N < 13$ mm, and

$b = 1{,}8\ N^{0,5}$ for $N \geq 13$ mm

where N is the geometric contact width of the gasket, in mm, as indicated in Fig 11(o)

m, y : Adimensional coefficients, whose values are given in Tab 7, depending on the type of gasket.

The adoption of one of the above-mentioned heads is subject to the Society’s approval depending upon its use. Types of heads not shown in Fig 10 and Fig 11 will be the subject of special consideration by the Society.

b) The thickness obtained by the formula in a) is “net” thickness, as it does not include any corrosion allowance. Unless a greater value is agreed in the vessel contract specification, the thickness obtained by the above formula is to be increased by 1 mm. See also [3.3.7].

Figure 8 : Connection of hemispherical head to the cylindrical shell

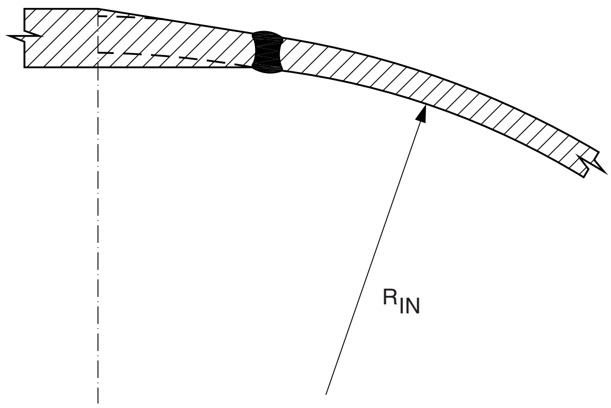


Figure 9 : Openings on dished heads

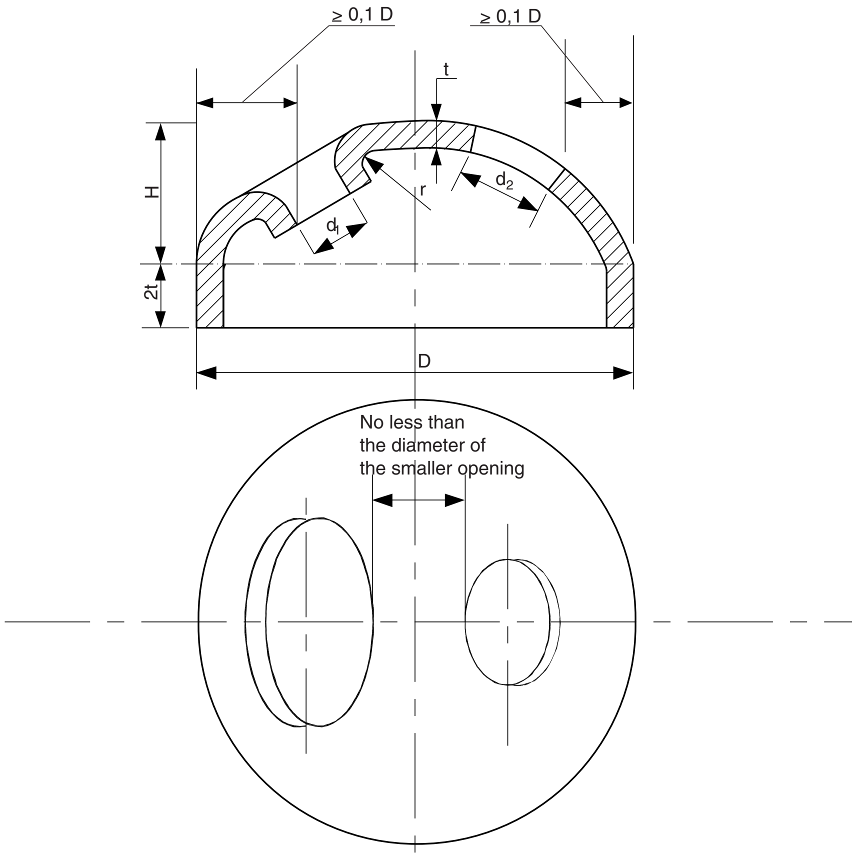


Figure 10 : Type of unstayed flt heads (1)

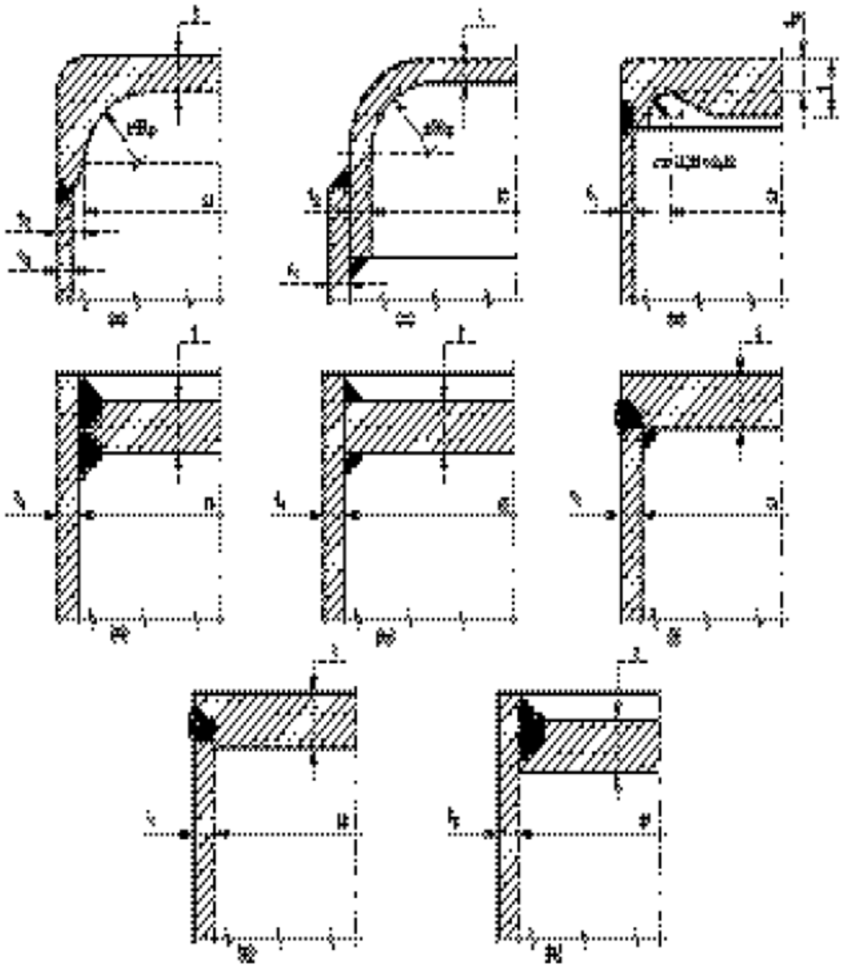
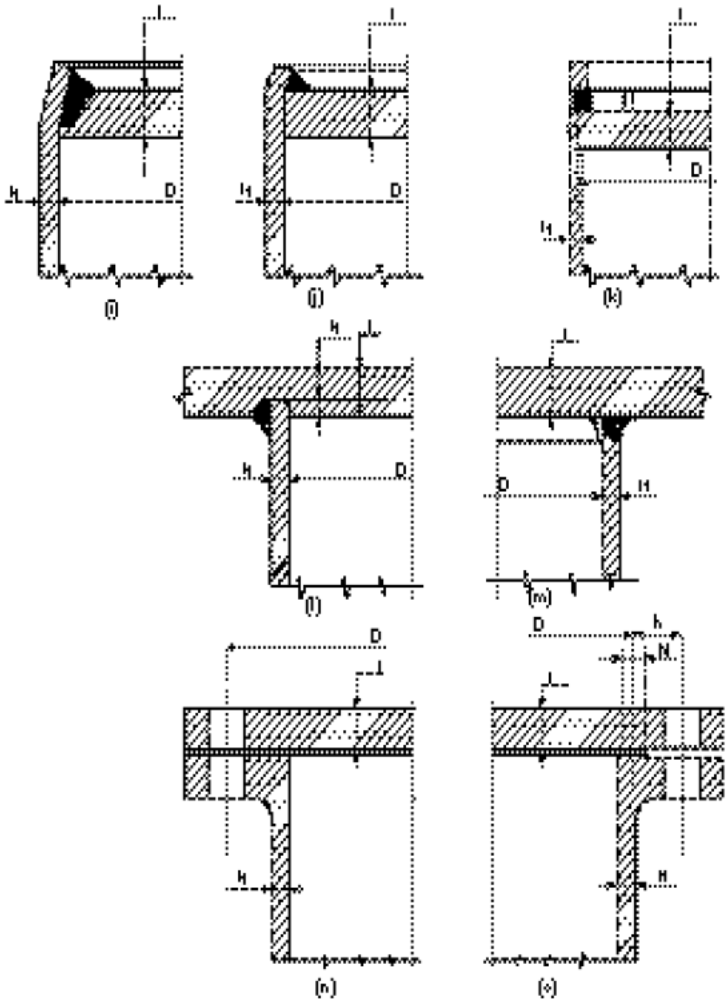


Figure 11 : Type of unstayed flt heads (2)



3.5.2 Stayed flat head minimum thickness

For the minimum thickness of stayed flat heads, see [3.8.4].

3.5.3 Compensation of openings in flat plates

Openings in flat plates for inspection purposes or for connection of fittings are to be compensated by reinforcement collars or by flanges.

In the latter case, the depth h of the flange, in mm, measured from the outer surface, is not to be less than the value obtained from the following formula:

$h = (t \cdot d_M)^{0,5}$

where t and d_M are the values, in mm, of the plate thickness and of the minimum width of the opening.

Table 7 : Coefficients m and y

Type of gasket	m	y
Self-sealing, metal or rubber (e.g. O-ring)	0	0
Rubber with cotton fabric	10	0,88
Rubber with reinforcing fabric with or without metal wire:		
- 3 layers	18	4,85
- 2 layers	20	6,4
- 1 layers	22	8,2
Synthetic fibre with suitable binders:		

Type of gasket	m	y
- 3 mm thick	16	3,5
- 1,5 mm thick	22	8,2
Organic fibre	14	2,4
Metal spiral lined with synthetic fibre:		
- Carbon Steel	20	6,4
- Stainless Steel	24	9,9
Synthetic fibre with plain metal lining:		
- Copper	28	14,0
- Iron	30	16,8
- Stainless steel	30	20,0
Solid metal:		
- Copper	38	28,7
- Iron	44	39,8
- Stainless steel	52	57,5

3.6 Nozzles

3.6.1 Thickness

a) The thickness of the nozzle attached to shells and headers of other pressure vessels is not to be less than the thickness required for the piping system attached to the vessel shell calculated at the vessel design pressure, and need not be greater than the thickness of the shell to which it is connected.

b) Where a branch is connected by screwing, the thickness of the nozzle is to be measured at the root of the thread.

3.6.2 Nozzle connection to vessel shell

a) In general, the axis of the nozzle is not to form an angle greater than 15° with the normal to the shell.

b) Fig 18, Fig 19, Fig 20 and Fig 21 show some typical acceptable connections of nozzles to shells. Other types of connections will be considered by the Society on a case by case basis.

3.7 Bottles containing pressurised gases

3.7.1 General

a) The following requirements apply to bottles intended to contain pressurised and/or liquefied gases at ambient temperature, made by seamless manufacturing processes.

b) In general, such bottles are to have an outside diameter not exceeding 420 mm, length not exceeding 2000 mm and capacity not exceeding 150 litres (see also [2.6.1]).

c) For bottles exceeding the above capacity and dimensions, the following requirements may be applied at the discretion of the Society.

3.7.2 Cylindrical shell

The wall thickness of the cylindrical shell is not to be less than the value t, in mm, determined by the following formula:

$$t = \frac{p_H D_E}{2K + p_H}$$

where:

p_H : Hydrostatic test pressure, in MPa. This pressure is to be taken as 1,5 times the setting pressure of the safety valves with the following exceptions:
- 25 MPa for CO_2 bottles
- For refrigerants, the value of hydrostatic test pressure is given in Part F, Chapter 8.

D_E : Outside diameter of tube, in mm

K : $R_{S,MIN}$ /1,3

$R_{S,MIN}$: Value of the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p\ 0,2}$), at the ambient temperature, in N/mm^2. In no case is the value $R_{S,MIN}$ to exceed:

- 0,75 R_m for normalised steels
- 0,90 R_m for quenched and tempered steels

3.7.3 Dished ends

Dished ends are to comply with the following requirements:

a) Hemispherical ends: the thickness of the ends is to be not less than the thickness calculated for spherical shells in accordance with [3.3.3].

b) Convex ends: see Fig 12.

c) Concave base ends: see Fig 13.

d) Ends with openings: see Fig 14.

e) Other types of ends will be specially considered by the Society.

3.8 Heat exchangers

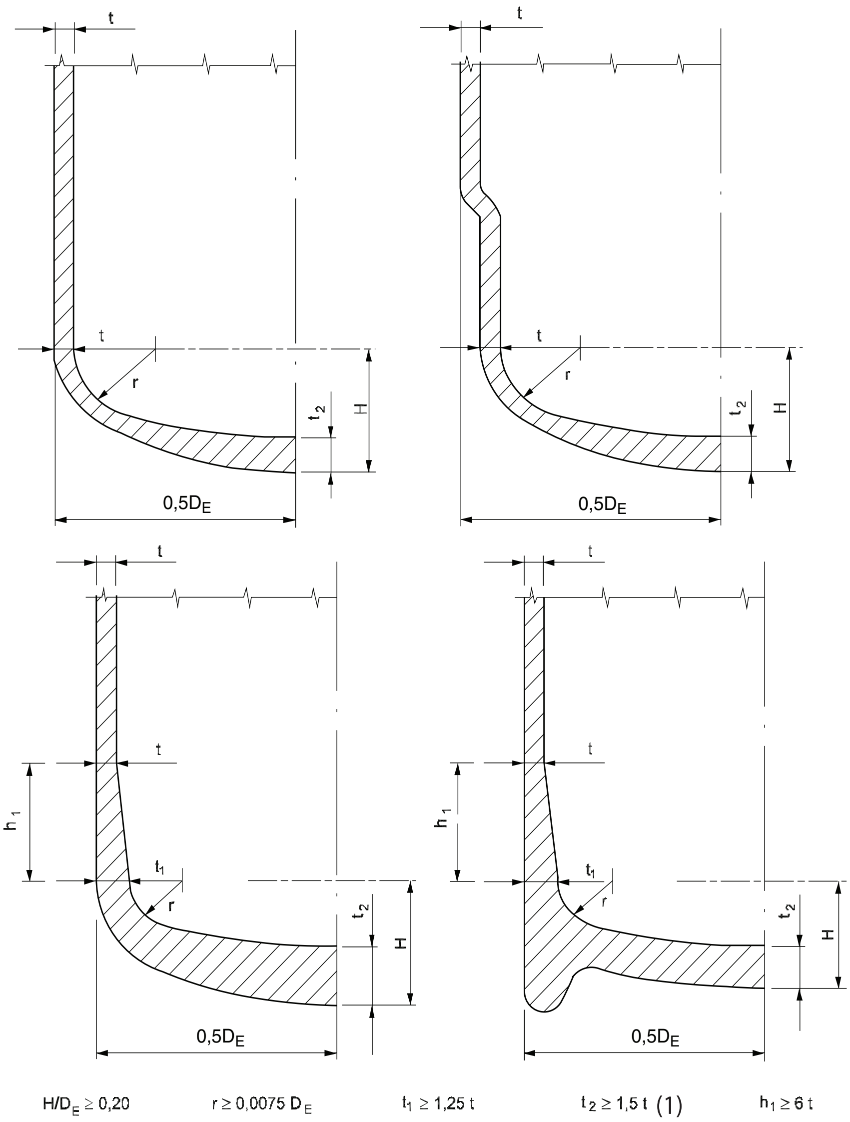
3.8.1 Scantlings

a) Vessels are to be designed in accordance with the applicable requirements stated in [3.3] and [3.4].

b) Tubes are to be designed in accordance with [3.7.5].

c) Tube plates are to be designed in accordance with a recognised Standard accepted by the Society.

Figure 12 : Dished convex ends



(1) : $t_2 > t$ in the case of dished ends manufactured from plates by deep drawing procedure, provided that $H/D_e > 0,4$ and thickness according to [3.4.3].

Figure 13 : Dished concave ends

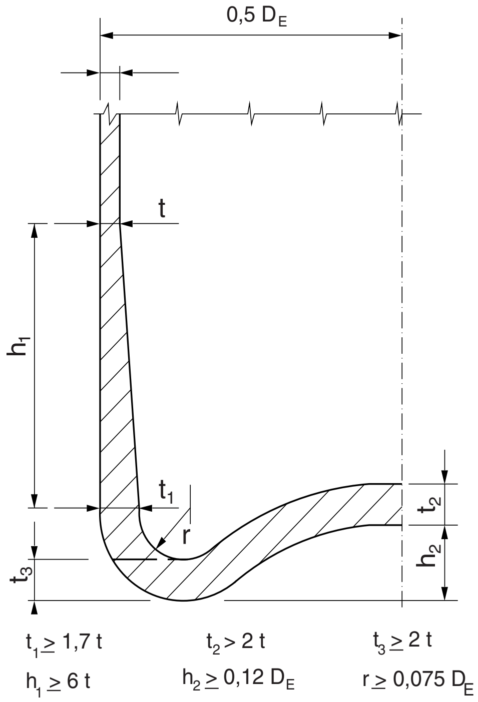
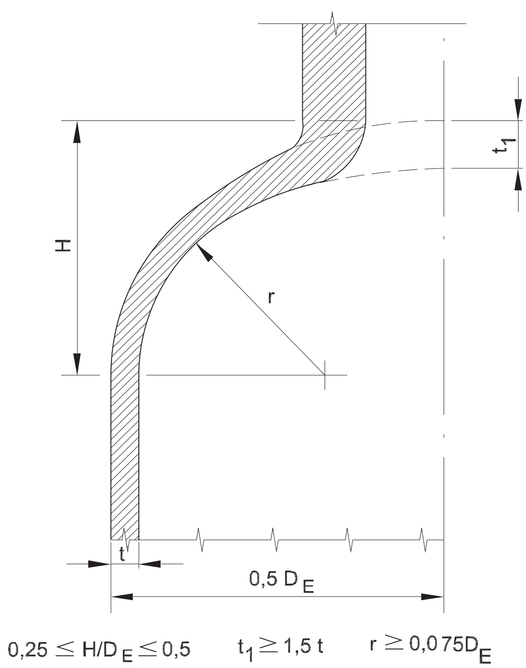


Figure 14 : Heads with openings



4 Design and construction - Fabrication and welding

4.1 General

4.1.1 Base materials

a) These requirements apply to boilers and pressure vessels made of steel of weldable quality.

b) Fabrication and welding of vessels made of other materials will be the subject of special consideration.

4.1.2 Welding

a) Weldings are to be performed in accordance with welding procedures approved by the Society.

b) Manual and semi-automatic welding is to be performed by welders qualified by the Society.

c) The conditions under which the welding procedures, welding equipment and welders operate are to correspond to those specified in the relevant approvals or qualifications.

d) Both ordinary and special electric arc welding processes are covered in the following requirements.

4.1.3 Cutting of plates

a) Plates are to be cut by flame cutting, mechanical machining or a combination of both processes. For plates having a thickness less than 25 mm, cold shearing is admitted provided that the sheared edge is removed by machining or grinding for a distance of at least one quarter of the plate thickness with a minimum of 3 mm.

b) For flame cutting of alloy steel plates, preheating is to be carried out if necessary.

c) The edges of cut plates are to be examined for laminations, cracks or any other defect detrimental to their use.

4.1.4 Forming of the plates

a) The forming processes are to be such as not to impair the quality of the material. The Society reserves the right to require the execution of tests to demonstrate the suitability of the processes adopted. Forming by hammering is not allowed.

b) Unless otherwise justified, cold formed shells are to undergo an appropriate heat treatment if the ratio of internal diameter after forming to plate thickness is less than 20. This heat treatment may be carried out after welding.

c) Before or after welding, hot formed plates are to be normalised or subjected to another treatment suitable for their steel grade, if hot forming has not been carried out within an adequate temperature range.

d) Plates which have been previously butt-welded may be formed under the following conditions:

- Hot forming:

  after forming, the welded joints are to be subjected to radiographic examination or equivalent. In addition, mechanical tests of a sample weld subjected to the same heat treatment are to be carried out.

- Cold forming

  cold forming is only allowed for plates having a thickness not exceeding:

  - 20 mm for steels having minimum ultimate tensile strength R_m between 360 N/mm^2 and 410 N/mm^2
  - 15 mm for steels having R_m between 460N/mm^2 and 510N/mm^2 as well as for steels 0,3Mo, 1Mn0,5Mo, 1Mn0,5MoV and 0,5Cr0,5Mo;

  cold forming is not allowed for steels 1Cr0,5Mo and 2,25Cr1Mo.

- Weld reinforcements are to be carefully ground smooth prior to forming.
- A proper heat treatment is to be carried out after forming, if the ratio of internal diameter to thickness is less than 36, for steels: 460 N/mm^2, 510 N/mm^2, 0,3Mo, 1Mn 0,5Mo, 1Mn 0,5MoV and 0,5Cr 0,5Mo.
- After forming, the joints are to be subjected to radiographic examination or equivalent and to a magnetic particle or liquid penetrant test.

4.2 Welding design

4.2.1 Main welded joints

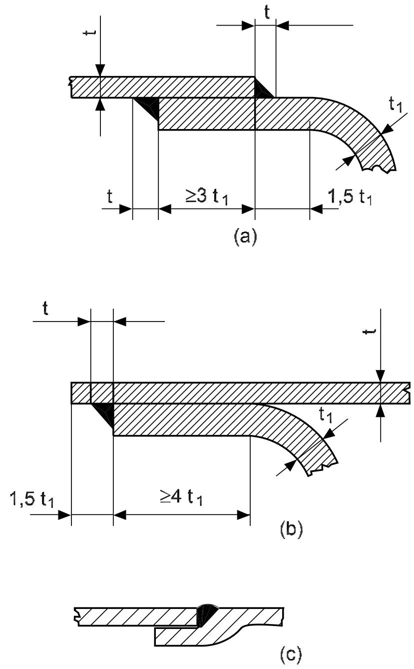
a) All joints of class 1 and 2 pressure parts of boilers and pressure vessels are to be butt-welded, with the exception of welding connecting flat heads or tube sheets to shells, for which partial penetration welds or fillet welds may be accepted.

b) Joints of class 3 pressure vessels are also subject to the requirement in a), however connection of dished heads to shells by lap welds may be accepted. Fig 15 shows some acceptable details of circumferential lap welds for class 3 pressure vessels.

4.2.2 Shell longitudinal and circumferential welds

Longitudinal and circumferential joints are to be welded from both sides of the plate. Welding from one side may be allowed only when there is evidence that the welding process permits a complete penetration and a sound weld root. If a backing strip is used, it is to be removed after welding and prior to any non-destructive examination. However, the backing strip may be retained in circumferential joints of class 2 vessels, having a thickness not exceeding 15 mm, and of class 3 vessels, provided that the material of the backing strip is such as not to adversely affect the weld.

Figure 15 : Example of acceptable lap-joints



Details (b) and (c) may be used only for pressure vessels having internal diameter less than 600mm.

4.2.3 Plates of unequal thickness

a) If plates of unequal thickness are butt-welded and the difference between thicknesses is more than 3 mm, the thicker plate is to be smoothly tapered for a length equal to at least four times the offset, including the width of the weld. For longitudinal joints the tapering is to be made symmetrically on both sides of the plate in order to obtain alignment of middle lines.

b) If the joint is to undergo radiographic examination, the thickness of the thicker plate is to be reduced to that of the thinner plate next to the joint and for a length of at least 30 mm.

4.2.4 Dished heads

a) For connection of a hemispherical end with a cylindrical shell, the joint is to be arranged in a plane parallel to that of the largest circle perpendicular to the axis of the shell and at such a distance from this plane that the tapering of the shell made as indicated in [4.2.3] is wholly in the hemisphere.

b) For torispherical ends made of parts assembled by welding, no welded joint is normally admitted along a parallel in the knuckle nor at a distance less than 50 mm from the beginning of the knuckle.

4.2.5 Welding location

The location of main welded joints is to be chosen so that these joints are not submitted to appreciable bending stresses.

4.2.6 Accessories and nozzles

a) Attachment of accessories by welds crossing main welds or located near such welds is to be avoided; where this is impracticable, welds for attachment of accessories are to completely cross the main welds rather than stop abruptly on or near them.

b) Openings crossing main joints or located near main joints are also to be avoided as far as possible.

c) Doubling plates for attachment of accessories such as fixing lugs or supports are to be of sufficient size to ensure an adequate distribution of loads on pressure parts; such doubling plates are to have well rounded corners. Attachment of accessories such as ladders and platforms directly on the walls of vessels such that they restrain their free contraction or expansion is to be avoided.

d) Welded connections of nozzles and other fittings, either with or without local compensation, are to be of a suitable type, size and preparation in accordance with the approved plans.

4.2.7 Connections of stays to tube plates

a) Where stays are welded, the cross-sectional area of the weld is to be at least 1,25 times the cross-section of the stay.

b) The cross-sectional area of the end welding of welded stay tubes is to be not less than 1,25 times the cross-sectional area of the stay tube.

4.2.8 Type of weldings

Fig 16, Fig 17, Fig 18, Fig 19, Fig 20, Fig 21, Fig 22, Fig 23, Fig 24 and Fig 25 indicate the type and size of weldings of typical pressure vessel connections. Any alternative type of welding or size will be the subject of special consideration by the Society.

4.3 Miscellaneous requirements for fabrication and welding

4.3.1 Welding position

a) As far as possible, welding is to be carried out in the downhand horizontal position and arrangements are to be foreseen so that this can be applied in the case of circumferential joints.

b) When welding cannot be performed in this position, tests for qualification of the welding process and the welders are to take account thereof.

4.3.2 Cleaning of parts to be welded

a) Parts to be welded are, for a distance of at least 25mm from the welding edges, to be carefully cleaned in order to remove any foreign matter such as rust, scale, oil, grease and paint.

b) If the weld metal is to be deposited on a previously welded surface, all slag or oxide is to be removed to prevent inclusions.

4.3.3 Protection against adverse weather conditions

a) Welding of pressure vessels is to be done in a sheltered position free from draughts and protected from cold and rain.

b) Unless special justification is provided, no welding is to be performed if the temperature of the base metal is less than 0°C.

4.3.4 Interruption in welding

If, for any reason, welding is stopped, care is to be taken on restarting to obtain a complete fusion.

4.3.5 Backing weld

When a backing weld is foreseen, it is to be carried out after suitable chiseling or chipping at the root of the first weld, unless the welding process applied does not call for such an operation.

4.3.6 Appearance of welded joints

a) Welded joints are to have a smooth surface without under-thickness; their connection with the plate surface is to be gradual without undercutting or similar defects.

b) The weld reinforcement of butt welds, on each side of the plate, is not to exceed the following thickness:
   - 2,5mm for plates having a thickness not exceeding 12mm
   - 3mm for plates having a thickness greater than 12mm but less than 25mm
   - 5mm for plates having a thickness at least equal to 25mm.

4.4 Preparation of parts to be welded

4.4.1 Preparation of edges for welding

a) Grooves and other preparations of edges for welding are to be made by machining, chipping or grinding. Flame cutting may also be used provided that the zones damaged by this operation are removed by machining, chipping or grinding. For alloy steel plates, preheating is to be provided, if needed, for flame cutting.

b) Edges prepared are to be carefully examined to check that there are no defects detrimental to welding.

Figure 16 : Types of joints for unstayed flat heads (1)

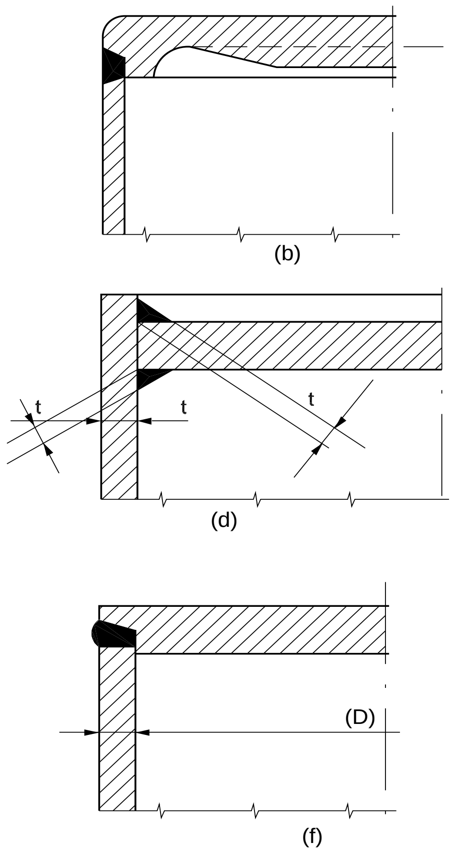


Figure 17 : Types of joint for unstayed flat heads (2)

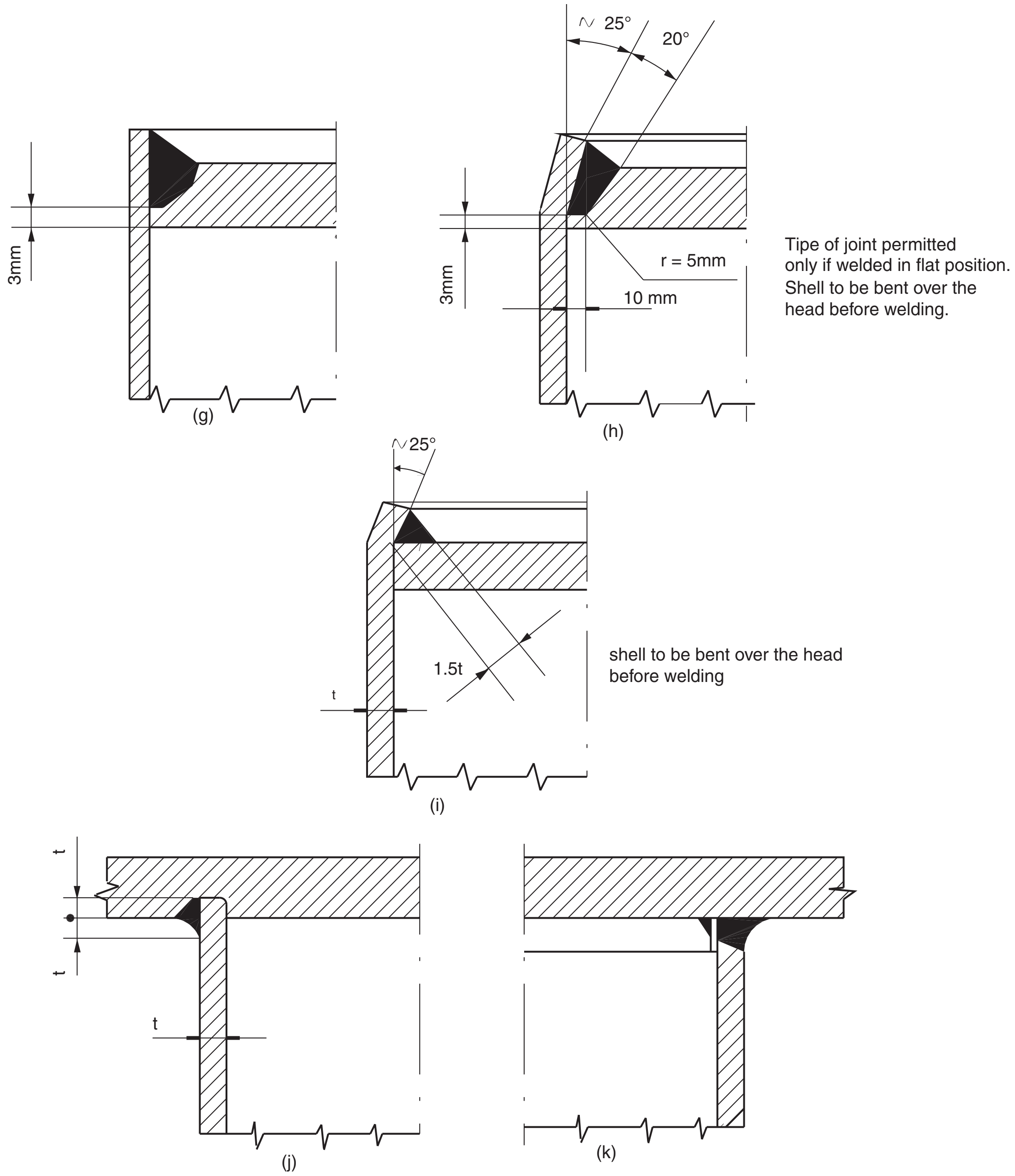


Figure 18 : Types of joints for nozzles and reinforcing rings (1)

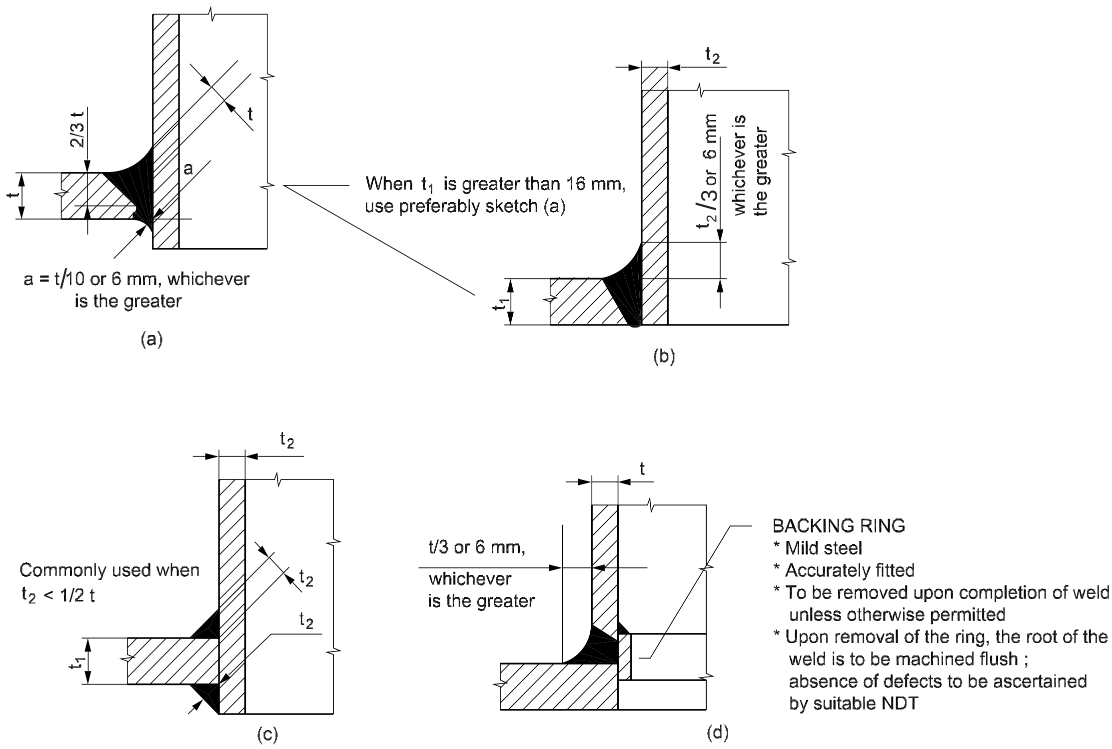


Figure 19 : Types of joint for nozzles and reinforcing rings (2)

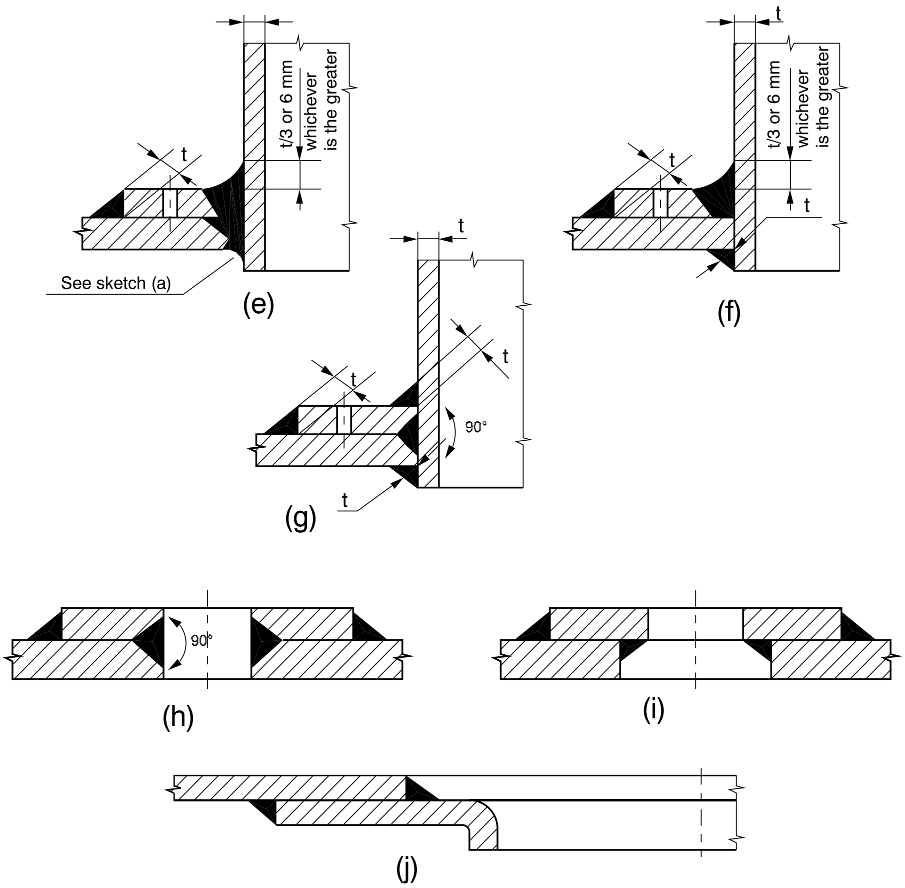


Figure 20 : Types of joint for nozzles and reinforcing rings (3)

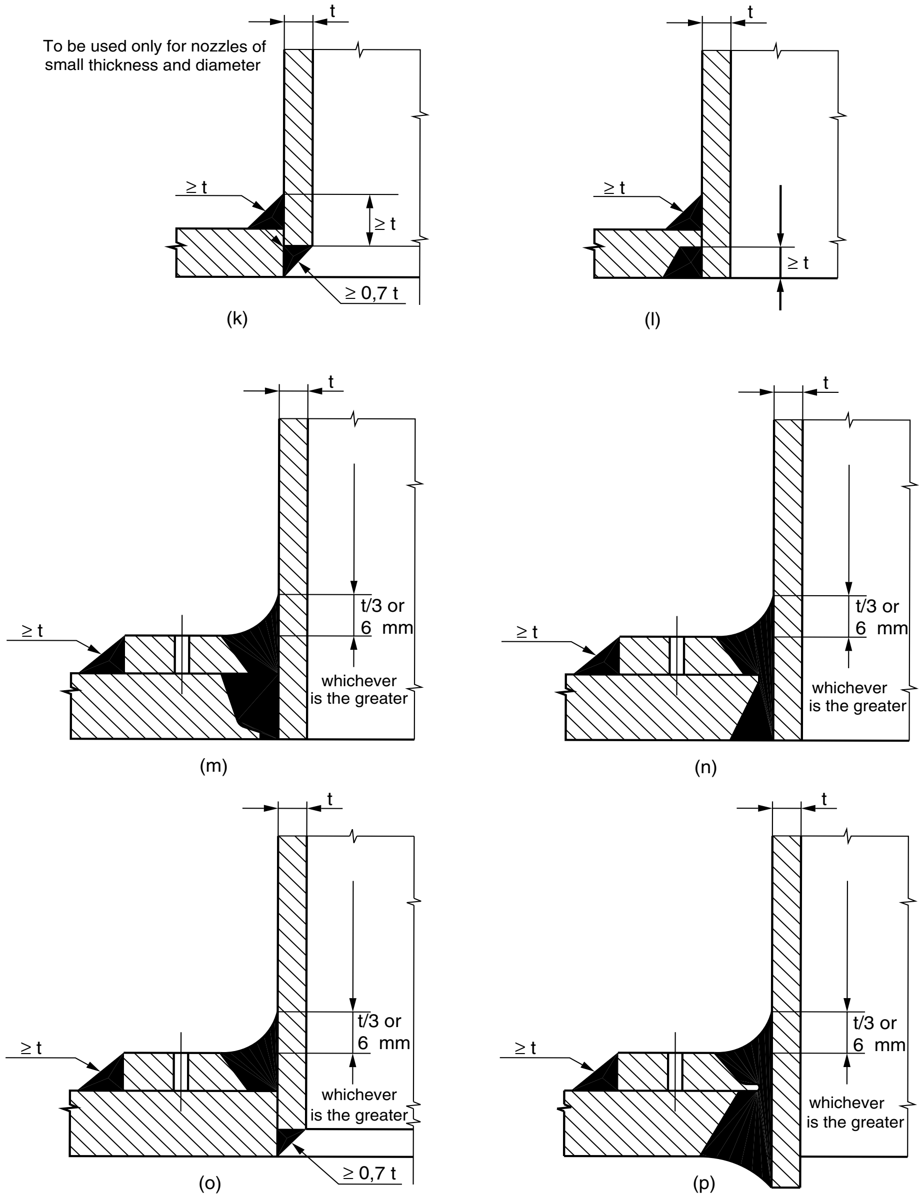
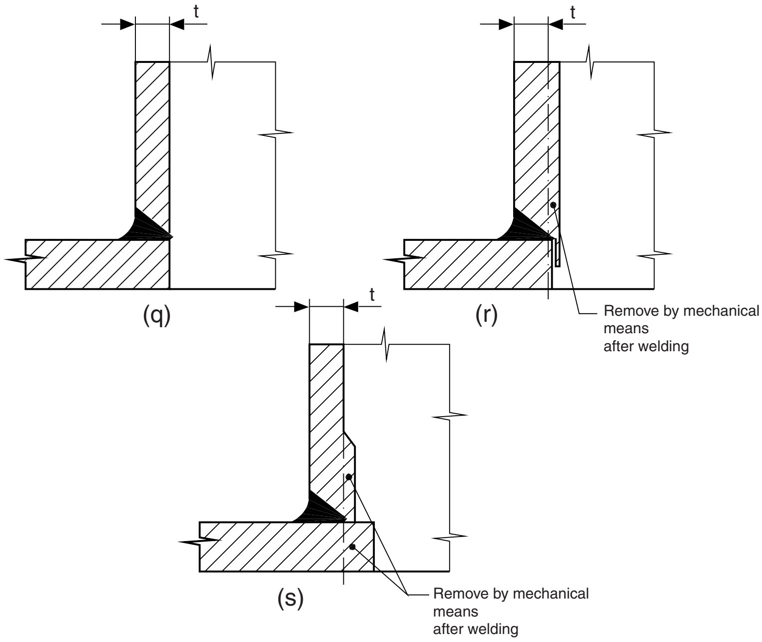


Figure 21 : Types of joints for nozzles (4)



Note: Where preparations of Fig 21 are carried out, the shell is to be carefully inspected to ascertain the absence of lamination.

Figure 22 : Types of joint for flanges to nozzles

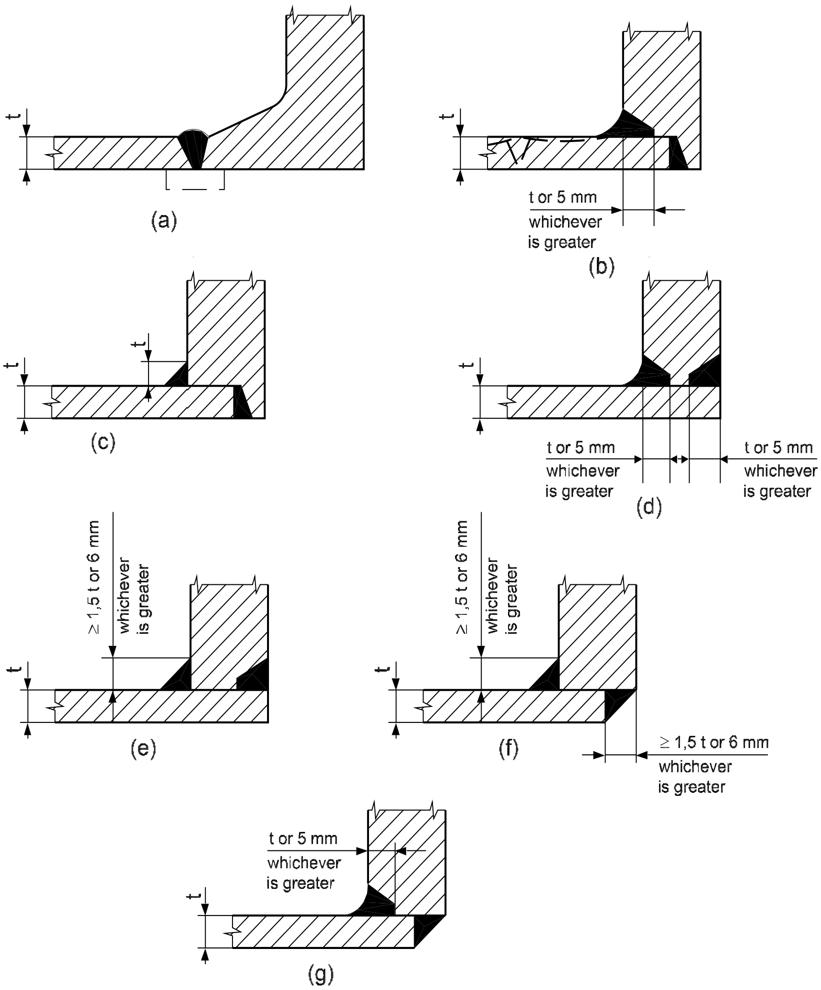


Figure 23 : Types of joint for tubesheets to shells (direct connection)

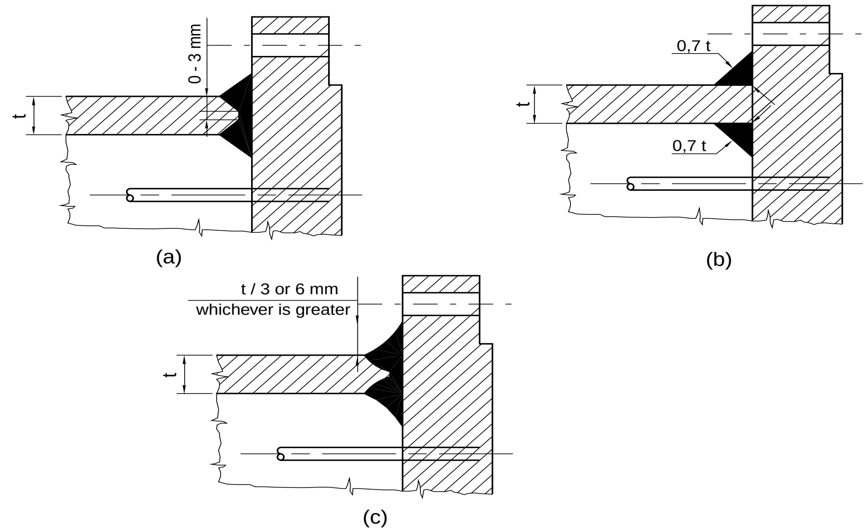
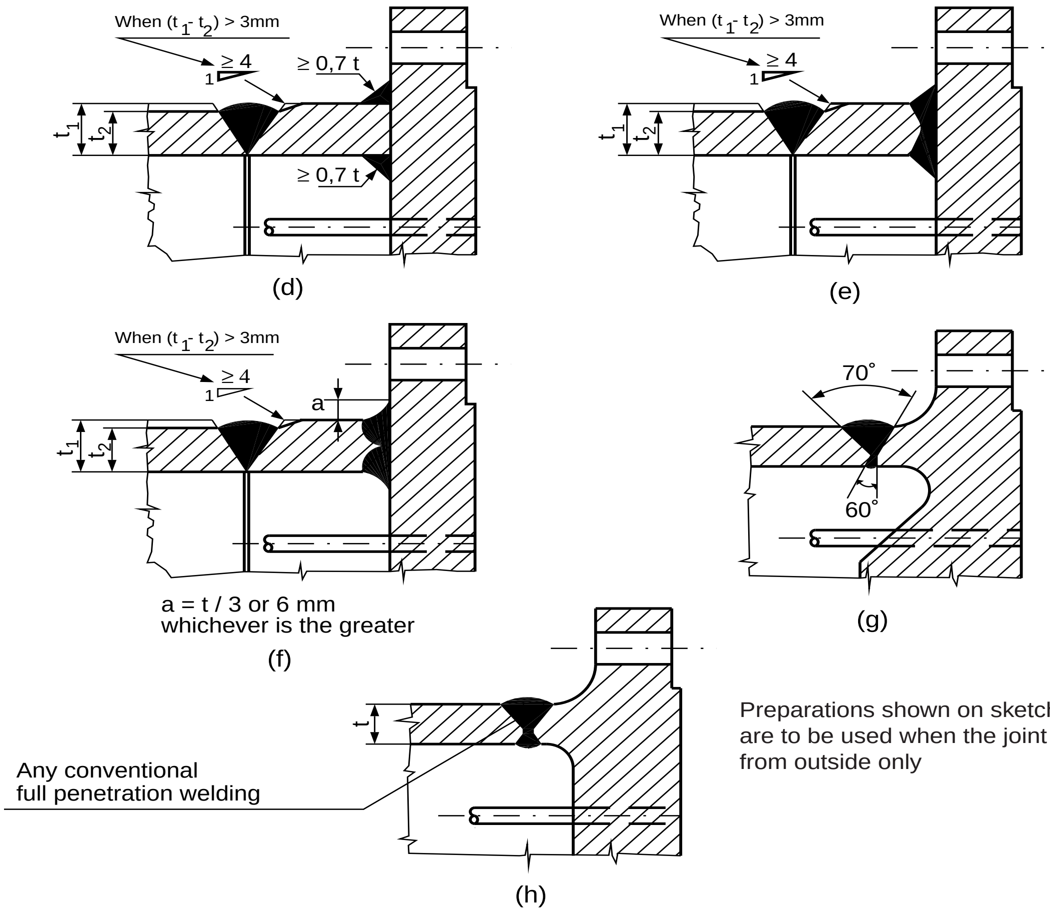
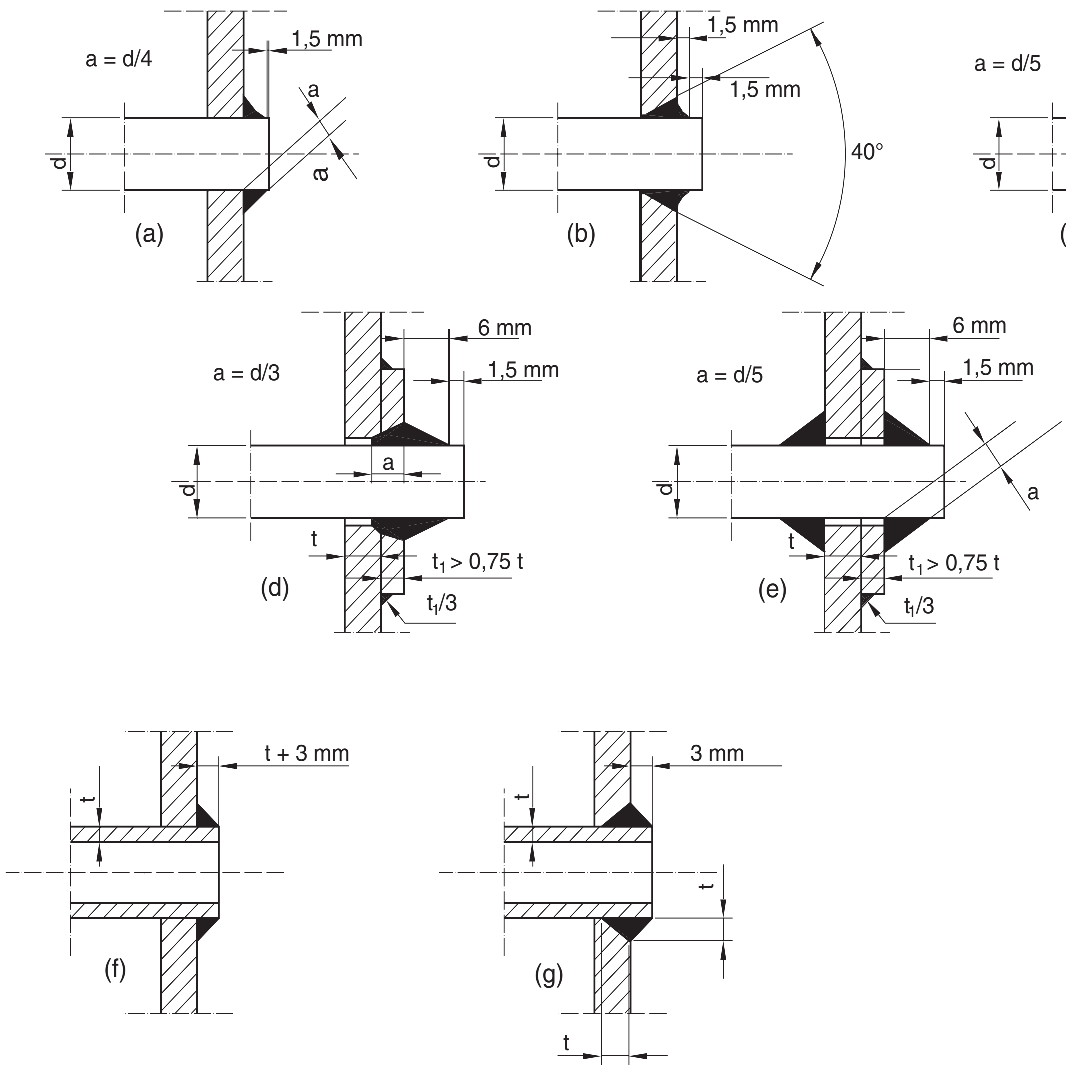


Figure 24 : Types of joints for tubesheets to shells (butt welded)



Preparations shown on sketches (d), (e) and (f) are to be used when the joint is accessible from outside only

Figure 25 : Type of joints for stays and stay tubes



4.4.2 Abutting of parts to be welded

a) Abutting of parts to be welded is to be such that surface misalignment of plates does not exceed:
- 10% of the thickness of the plate with a maximum of 3 mm for longitudinal joints
- 10% of the thickness of the plate plus 1 mm with a maximum of 4 mm for circumferential joints.

b) For longitudinal joints, middle lines are to be in alignment within 10% of the thickness of the thinner plate with a maximum of 3 mm.

c) Plates to be welded are to be suitably retained in position in order to limit deformation during welding. The arrangements are to be such as to avoid modification of the relative position of parts to be welded and misalignment, after welding, exceeding the limits indicated above.

d) Temporary welds for abutting are to be carried out so that there is no risk of damage to vessel shells. Such welds are to be carefully removed after welding of the vessel and before any heat treatment. Non-destructive testing of the corresponding zones of the shell may be required by the Surveyor if considered necessary.

e) Accessories such as doubling plates, brackets and stiffeners are to be suitable for the surface to which they are to be attached.

4.5 Tolerances after construction

4.5.1 General

The sizes and shape of vessels are to be checked after welding for compliance with the design taking into account the tolerances given below. The Society reserves the right to stipulate smaller values for these tolerances for vessels subjected to special loads.

Any defect in shape is to be gradual and there is to be no flat area in way of welded joints.

Measurements are to be taken on the surface of the parent plate and not on the weld or other raised part.

4.5.2 Straightness

The straightness of cylindrical shells is to be such that their deviation from the straight line does not exceed 0,6% of their length, with a maximum of 15 mm for each 5 m of length.

4.5.3 Out-of-roundness

a) Out-of-roundness of cylindrical shells is to be measured either when set up on end or when laid flat on their sides; in the second case, measures of diameters are to be repeated after turning the shell through 90° about its axis and out-of-roundness is to be calculated from the average of the two measures of each diameter.

b) For any transverse section, the difference between the maximum and minimum diameters is not to exceed 1% of the nominal diameter D with a maximum of:

   (D + 1250) / 200, D being expressed in mm.

   For large pressure vessels, this limit may be increased by a maximum of 0,2% of the internal diameter of the vessel. Any possible out-of-roundness within the above limit is to be gradual and there are to be no localised deformations in way of the welded joints.

4.5.4 Irregularities

Irregularities in profile of cylindrical shells, checked by a 20° gauge, are not to exceed 5% of the thickness of the plate plus 3 mm. This value may be increased by 25% if the length of the irregularity does not exceed one quarter of the distance between two circumferential seams, with a maximum of 1 mm.

4.6 Preheating

4.6.1

a) Preheating, to be effectively maintained during the welding operation, may be required by the Society when deemed necessary in relation to a number of circumstances, such as the type of steel, thickness of the base material, welding procedure and technique, type of restraint, and heat treatment after welding, if any.

b) The preheating temperature will be determined accordingly. However, a preheating temperature of approximately 150°C is required for 0,5Mo or 1Cr0,5Mo type steel, and approximately 250°C for 2,25Cr1Mo type steel.

c) These requirements also apply to welding of nozzles, fittings, steam pipes and other pipes subject to severe conditions.

4.7 Post-weld heat treatment

4.7.1 General

a) When post-weld heat treatment of a vessel is to be carried out, such treatment is to consist of:
   - heating the vessel slowly and uniformly up to a temperature suitable for the grade of steel
   - maintaining this temperature for a duration determined in relation to the actual thickness t_A of the vessel and the grade of steel
   - slowly cooling the vessel in the furnace down to a temperature not exceeding 400°C, with subsequent cooling allowed out of the furnace in still air.

b) As far as possible, vessels are to be heat treated in a single operation. However, when the sizes of the vessels are such that heat treatment requires several operations, care is to be taken such that all the parts of the vessels undergo heat treatment in a satisfactory manner. In particular, a cylindrical vessel of great length may be treated in sections in a furnace if the overlap of the heated sections is at least 1500 mm and if parts outside the furnace are lagged to limit the temperature gradient to an acceptable value.

4.7.2 Thermal stress relieving

Upon completion of all welding, including connections of nozzles, doublers and fittings, pressure vessels of classes 1 and 2, boilers and associated parts are to be subjected to an effective stress relieving heat treatment in the following cases:

- Pressure vessels of classes 1 and 2 containing fluids at a temperature not less than the ambient temperature, where the thickness exceeds that indicated in Tab 8

Applications at temperatures less than the ambient temperature and/or steels other than those indicated above will be the subject of special consideration by the Society.

Stress relieving heat treatment will not be required when the minimum temperature of the fluid is at least 30°C higher than the KV-notch impact test temperature specified for the steel; this difference in temperature is also to be complied with for welded joints (both in heat-affected zones and in weld metal).

Pressure vessels and pipes of class 3 and associated parts are not required to be stress relieved, except in specific cases.

4.7.3 Heat treatment procedure

The temperature of the furnace at the time of introduction of the vessel is not to exceed 400°C.

a) The heating rate above 400°C is not to exceed:

   1) 220°C per hour if the maximum thickness is not more than 25 mm, or

   2) $(5500/t_A)$°C per hour, with a minimum of 55°C per hour, if the maximum thickness t_A, in mm, is more than 25 mm

b) The absolute value of the cooling rate in the furnace is not to exceed:

   1) 280°C per hour if the maximum thickness is not more than 25 mm, or

   2) $(7000/t_A)$°C per hour, with a minimum of 55°C per hour, if the maximum thickness t_A, in mm, is more than 25 mm.

Unless specially justified, heat treatment temperatures and duration for maintaining these temperatures are to comply with the values in Tab 9.

Table 8 : Thermal stress relieving

Grade	Thickness (mm) above which post-weld heat treatment is required	
	Boilers	Unfired pressure vessels
R_m = 360 N/mm^2 Grade HA R_m = 410 N/mm^2 Grade HA	14,5	14,5
R_m = 360 N/mm^2 Grade HB R_m = 410 N/mm^2 Grade HB	20	30
R_m = 360 N/mm^2 Grade HD R_m = 410 N/mm^2 Grade HD	20	38
R_m = 460 N/mm^2 Grade HB R_m = 510 N/mm^2 Grade HB	20	25
R_m = 460 N/mm^2 Grade HD R_m = 510 N/mm^2 Grade HD	20	35
0,3Mo 1Mn 0,5Mo 1Mn 0,5MoV 0,5Cr 0,5Mo	20	20
1Cr 0,5Mo 2,25Cr1Mo	all	all

Table 9 : Heat treatment procedure

Grade	Temperatures	Time per 25 mm of maximum thickness	Minimum time
Carbon steels	580-620°C	1 hour	1 hour
0,3Mo 1Mn 0,5Mo 1Mn 0,5MoV 0,5Cr 0,5Mo	620-660°C	1 hour	1 hour
1Cr 0,5Mo	620-660°C	1hour	2 hours
2,25Cr 1Mo	600-750°C **(1)**	2 hours	2 hours
(1) The temperature is to be chosen, with a tolerance of ±20°C, in this temperature range in order to obtain the required mechanical characteristics			

4.7.4 Alternatives

When, for special reasons, heat treatment is carried out in conditions other than those given in [4.7.2], all details regarding the proposed treatment are to be submitted to the Society, which reserves the right to require tests or further investigations in order to verify the efficiency of such treatment.

4.7.5 Execution of heat treatment

Furnaces for heat treatments are to be fitted with adequate means for controlling and recording temperature; temperatures are to be measured on the vessel itself. The atmosphere in the furnaces is to be controlled in order to avoid abnormal oxidation of the vessel.

4.7.6 Treatment of test plates

Test plates are normally to be heated at the same time and in the same furnace as the vessel.

When separate heat treatment of test plates cannot be avoided, all precautions are to be taken such that this treatment is carried out in the same way as for the vessel, specifically with regard to the heating rate, the maximum temperature, the duration for maintaining this temperature and the cooling conditions.

4.7.7 Welding after heat treatment

a) Normally, welding after heat treatment is only allowed if:
   - the throat of welding fillets does not exceed 10 mm
   - the largest dimension of openings in the vessel for the accessories concerned does not exceed 50 mm.

b) Any welding of branches, doubling plates and other accessories on boilers and pressure vessels after heat treatment is to be submitted for special examination by the Society.

4.8 Welding samples

4.8.1 Test plates for welded joints

a) Test plates of sufficient size, made of the same grade of steel as the shell plates, are to be fitted at each end of the longitudinal joints of each vessel so that the weld in the test plates is the continuation of these welded joints. There is to be no gap when passing from the deposited metal of the joint to the deposited metal of the test plate.

b) No test plate is required for circumferential joints if these joints are made with the same process as longitudinal joints. Where this is not the case, or if there are only circumferential joints, at least one test plate is to be welded separately using the same welding process as for the circumferential joints, at the same time and with the same welding materials.

c) Test plates are to be stiffened in order to reduce as far as possible warping during welding. The plates are to be straightened prior to their heat treatment which is to be carried out in the same conditions as for the corresponding vessel (see also [4.7.6]).

d) After radiographic examination, the following test pieces are to be taken from the test plates:
   - one test piece for tensile test on welded joint
   - two test pieces for bend test, one direct and one reverse
   - three test pieces for impact test
   - one test piece for macrographic examination.

4.8.2 Mechanical tests of test plates

a) The tensile strength on welded joint is not to be less than the minimum specified tensile strength of the plate.

b) The bend test pieces are to be bent through an angle of 180° over a former of 4 times the thickness of the test piece. There is to be no crack or defect on the outer surface of the test piece exceeding in length 1,5 mm transversely or 3 mm longitudinally. Premature failure at the edges of the test piece is not to lead to rejection. As an alternative, the test pieces may be bent through an angle of 120° over a former of 3 times the thickness of the test piece.

c) The impact energy measured at 0°C is not to be less than the values given in Part D for the steel grade concerned.

d) The test piece for macrographic examination is to permit the examination of a complete transverse section of the weld. This examination is to demonstrate good penetration without lack of fusion, large inclusions and similar defects. In case of doubt, a micrographic examination of the doubtful zone may be required.

4.8.3 Re-tests

a) If one of the test pieces yields unsatisfactory results, two similar test pieces are to be taken from another test plate.

b) If the results for these new test pieces are satisfactory and if it is proved that the previous results were due to local or accidental defects, the results of the re-tests may be accepted.

4.9 Specific requirements for class 1 vessels

4.9.1 General

The following requirements apply to class 1 pressure vessels, as well as to pressure vessels of other classes, whose scantlings have been determined using an efficiency of welded joint e greater than 0,90.

4.9.2 Non-destructive tests

a) All longitudinal and circumferential joints of class 1 vessels are to be subject of 100% radiographic or equivalent examination with the following exceptions:

   - for pressure vessels or parts designed to withstand external pressures only, at the Society’s discretion, the extent may be reduced up to approximately 30% of the length of the joints. In general, the positions included in the examinations are to include all welding crossings;
   - for vessels not intended to contain toxic or dangerous matters, made of carbon steels having thickness below 20 mm when the joints are welded by approved automatic processes at the Society’s discretion, the extent may be reduced up to approximately 10% of the length of the joints. In general, the positions included in the examinations are to include all welding crossings;
   - for circumferential joints having an external diameter not exceeding 175 mm, at the Society’s discretion, the extent may be reduced up to approximately 10% of the total length of the joints.

b) Fillet welds for parts such as doubling plates, branches or stiffeners are to undergo a spot magnetic particle test for at least 10% of their length. If magnetic particle tests cannot be used, it is to be replaced by liquid penetrant test.

c) Welds for which non destructive tests reveal unacceptable defects, such as cracks or areas of incomplete fusion, are to be rewelded and are then to undergo a new non destructive examination

4.9.3 Number of test samples

a) During production, at least one test plate for each 20 m of length (or fraction) of longitudinal weldings is to be tested as per [4.8.2].

b) During production, at least one test plate for each 30 m of length (or fraction) of circumferential welding is to be tested as per [4.8.2].

c) When several vessels made of plates of the same grade of steel, with thicknesses varying by not more than 5 mm, are welded successively, only one test plate may be accepted per each 20 m of length of longitudinal joints (or fraction) and per each 30 m of circumferential welding (or fraction) provided that the welders and the welding process are the same. The thickness of the test plates is to be the greatest thickness used for these vessels.

4.10 Specific requirements for class 2 vessels

4.10.1 General

For vessels whose scantlings have been determined using an efficiency of welded joint e greater than 0,90, see [4.9.1].

4.10.2 Non-destructive tests

All longitudinal and circumferential joints of class 2 vessels are to be subjected to 10% radiographic or equivalent examination. This extension may be extended at the Society's discretion based on the actual thickness of the welded plates.

As specified in Tab 5, where a joint efficiency of 0,75 is used in the formula for the calculation of the thickness of the vessel, the radiographic and the ultrasonic examinations may be omitted.

This assumes, however, that the Surveyor of the Society will adequately follow all the welding phases and that checks are completed by any non-destructive examinations deemed necessary.

4.10.3 Number of test samples

In general, the same requirements of [4.9.3] apply also to class 2 pressure vessels. However, test plates are required for each 50 m of longitudinal and circumferential weldings (or fraction).

4.11 Specific requirements for Class 3 vessels

4.11.1 For vessels whose scantlings have been determined using an efficiency of welded joint e greater than 0,90, see [4.9.1].

Heat treatment, mechanical tests and non-destructive tests are not required for welded joints of other Class 3 vessels.

5 Design and construction - Control and monitoring

5.1 Pressure vessel instrumentation

5.1.1

a) Pressure vessels are to be fitted with the necessary devices for checking pressure, temperature and level, where it is deemed necessary.

b) In particular, each air pressure vessel is to be fitted with a local manometer.

5.2 Control and monitoring

5.2.1

In addition to those of this item [5.4], the general requirements given in Chapter 3 apply.

In the case of s with automation notations, the requirements in Pt F, Ch 2 also apply.

5.2.2

Tab 10 summarise the control and monitoring requirements for incinerators.

Note 1: Some departures from Tab 10 may be accepted by the Society in the case of s with a restricted navigation notation.

Table 10 : Incinerators *(1/1/2025)*

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Incinerator			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Flame failure	X			X			
Furnace temperature	H			X			
Exhaust gas temperature	H						
Fuel oil pressure		local					

6 Arrangement and installation

6.1 Foundations

6.1.1 For boilers and pressure vessels bolting down to their foundations, see Sec 1, [3.3.1]. Where necessary, they are also to be secured to the adjacent hull structures by suitable ties.

Where chocks are required to be fitted between the boilers and their foundations, they are to be of cast iron or steel.

7 Material test, workshop inspection and testing, certification

7.1 Material testing

7.1.1 General

Materials, including welding consumables, for the constructions of boilers and pressure vessels are to be certified by the material manufacturer in accordance with the appropriate material specification.

7.1.2 Class 1 pressure vessels and heat exchangers

In addition to the requirement in [7.1.1], testing of materials intended for the construction of pressure parts of class 1 pressure vessels and heat exchangers is to be witnessed by the Surveyor.

This requirement may be waived at the Society's discretion for mass produced small pressure vessels (such as accumulators for valve controls, gas bottles, etc.).

7.2 Workshop inspections

7.2.1 Individually produced class 1 and 2 pressure vessels

The construction, fitting and testing of boilers and individually produced class 1 and 2 pressure vessels are to be attended by the Surveyor, at the builder's facility.

7.2.2 Mass produced pressure vessels

Construction of mass produced pressure vessels which are type approved by the Society need not be attended by the Surveyor. Reference is to be made to Pt A, Ch 2, App 3.

7.3 Hydrostatic tests

7.3.1 General

Hydrostatic tests of all class 1, 2 and 3 pressure vessels are to be witnessed by the Surveyor with the exception of mass produced pressure vessels which are built under the conditions stated in [7.2.2].

7.3.2 Testing pressure

a) Upon completion, pressure parts of boilers and pressure vessels are to be subjected to a hydraulic test under a pressure p_t defined below as a function of the design pressure p:
   - $p_t = 1,5\ p$ where $p \le 4$ MPa
   - $p_t = 1,4\ p + 0,4$ where $4 \text{ MPa} < p \le 25$ MPa
   - $P_t = p + 10,4$ where $p > 25$ MPa

b) The test pressure may be determined as a function of a pressure lower than p; however, in such case, the setting and characteristics of the safety valves and other overpressure protective devices are also to be determined and blocked as a function of this lower pressure.

c) If the design temperature exceeds 300°C, the test pressure p_t is to be as determined by the following formula:

$$p_t = 1,5 \cdot \frac{K_{100}}{K} \cdot p$$

where:

p : Design pressure, in MPa

K_{100} : Permissible stress at 100°C, in N/mm^2

K : Permissible stress at the design temperature, in N/mm^2

d) Consideration is to be given to the reduction of the test pressure below the values stated above where it is necessary to avoid excessive stress. In any event, the general membrane stress is not to exceed 90% of the yield stress at the test temperature.

e) Economisers which cannot be shut off from the boiler in any working condition are to be submitted to a hydraulic test under the same conditions as the boilers.

f) Economisers which can be shut off from the boiler are to be submitted to a hydraulic test at a pressure determined as a function of their actual design pressure p.

7.3.3 Hydraulic test of pressure vessel accessories

a) Pressure vessel accessories are to be tested at a pressure p_t which is not less than 1,5 times the design pressure p of the vessels to which they are attached.

b) The test pressure may be determined as a function of a pressure lower than p; however, in such case, the setting and characteristics of the safety valves and other overpressure protective devices are also to be determined and blocked as a function of this lower pressure.

7.3.4 Hydraulic test procedure

The hydraulic test specified in [7.3.1] is to be carried out after all openings have been cut out and after execution of all welding work and of the heat treatment, if any. The vessel to be tested is to be presented without lagging, paint or any other lining and the pressure is to be maintained long enough for the Surveyor to proceed with a complete examination.

7.4 Certification

7.4.1 Certification of individually produced pressure vessels

Boilers and individually produced pressure vessels of classes 1 and 2 are to be certified by the Society in accordance with the procedures stated in Part D.

7.4.2 Mass produced pressure vessels

Small mass produced pressure vessels of classes 1 and 2 may be accepted provided they are type approved by the Society in accordance with the procedures stated in Part A.

7.4.3 Pressure vessels not required to be certified

The Manufacturer's certificate, including detail of tests and inspections, is to be submitted to the Society for pressure vessels not required to be certified by the Society. The Society reserves the right to require confirmatory hydrostatic tests in the presence of the Surveyor on a case by case basis, based on the criticality and service of the pressure vessel.

7.5 Type approved pressure vessels

7.5.1 Issue of Tasneef Type Approval Certificate

The pressure vessels to which this Section is applicable according to [1.1.1] as an alternative may be type approved by The Society when accepted in Pt A, Ch 2, App 3.

For a particular type of pressure vessel, a Tasneef Type Approval Certificate valid for 3 years can be obtained by the Manufacturer by testing a prototype according to the requirements contained in [7].

The validity of the certificate in the course of the 3 years is subject to satisfactory results of shop trials witnessed by a Tasneef Surveyor; the periodicity and procedures are to be agreed with The Society on a case-by-case basis.

During the period of the Certificate's validity, and for the next pressure vessels of the same type, the tests required by the Rules can be carried out by the Manufacturer, who will issue a Certificate of conformity to the prototype.

7.5.2 Renewal of Tasneef Type Approval Certificate

For the renewal of the Tasneef Type Approval Certificate, the tests to be carried out will be specified in a scheme to be agreed with The Society.

SECTION 6 GEARING

1 General

1.1 Application

1.1.1

Unless otherwise specified, the requirements of this section apply to:

- reduction and/or reverse gears intended for propulsion plants with a transmitted power of 220 kW and above
- other reduction and step-up gears with a transmitted power of 110 kW and above, intended for essential service auxiliary machinery.

All other gears are to be designed and constructed according to sound marine practice and delivered with the relevant works' certificate (see Pt D, Ch 1, Sec 1, [4.2.3]).

Gearing approved prior to the application date and having a documented satisfactory service experience may be exempted from application of these Rules.

The provisions of Article [2] apply only to cylindrical involute spur or helical gears with external or internal teeth.

Additional requirements for gears fitted to s having an ice notation are given in Part F, Chapter 9.

Some departure from the requirements of this Section may be accepted by the Society in cases of gears fitted to s having short range navigation notation.

Alternative calculations based on a recognized standard may be submitted by the manufacturer of the gears and will be given special consideration by the Society.

[5] and [6] are applicable when requested in accordance with the relevant Table of Pt A, Ch 2, App 3.

1.2 Documentation to be submitted

1.2.1 Documents

Before starting construction, all plans, specifications and calculations listed in Tab 1 are to be submitted to the Society.

Table 1 : Documents to be submitted for gearing

No.	I/A **(1)**	Document **(2)**
1	A	Constructional drawings of shafts and flanges
2	A	Constructional drawings of pinions and wheels, including: a) specification and details of hardening procedure: • core and surface mechanical characteristics • diagram of the depth of the hardened layer as a function of hardness values b) specification and details of the finishing procedure: • finishing method of tooth flanks (hobbing, shaving, lapping, grinding, shot-peening) • surface roughness for tooth flank and root fillet • tooth flank corrections (helix modification, crowning, tip-relief, end-relief), if any • grade of accuracy according to ISO 1328-1:2013
3	A	Shrinkage calculation for shrunk-on pinions, wheels rims and/or hubs with indication of the minimum and maximum shrinkage allowances
4	A	Calculation of load capacity of the gears
5	A / I **(3)**	Constructional drawings of casings
6	A	Functional diagram of the lubricating system, with indication of: • specified grade of lubricating oil • expected oil temperature in service • kinematic viscosity of the oil

No.	I/A **(1)**	Document **(2)**
7	A	Functional diagram of control, monitoring and safety systems
8	I	Longitudinal and transverse cross-sectional assembly of the gearing, with indication of the type of clutch
9	I	Data form for calculation of gears
(1) A = to be submitted for approval, in four copies I = to be submitted for information, in duplicate. **(2)** Constructional drawings are to be accompanied by the specification of the materials employed including the chemical composition, heat treatment and mechanical properties and, where applicable, the welding details, welding procedure and stress relieving procedure. **(3)** "A" for welded casing, "I" otherwise		

1.2.2 Data

The data listed in Tab 2 are to be submitted with the documents required in [1.2.1].

Table 2 : Data to be submitted for gearing

No.	Description of the data
1	Type of driving and driven machines and, if provided, type of flexible coupling
2	Maximum power transmitted by each pinion in continuous running and corresponding rotational speed, for all operating conditions, including clutching-in
3	Modules of teeth for pinion and wheels
4	Pressure angle and helix angle
5	Tooth profiles of pinions and wheels together with tip diameters and fillet radii
6	Operating centre distance
7	Addendum of the cutting tool
8	Common face width, operating pitch diameter
9	Data related to the bearings: • type, characteristics and designed service life of roller bearings • materials and clearances of plain bearings • position of each gear in relation to its bearings
10	Torsional vibration data (inertia and stiffness)

1.3 Light duty e medium duty gears (1/1/2025)

1.3.1 General

Gears intended for light duty and medium duty operating profiles, as defined in Sec 2, [1.6.1],may be adopted. For such gears inferior coefficients than the ones provided in this section may be used. The Manufacturer demanding the approval of light duty or medium duty operating profile is requested to declare contextually with the demand the following parameters:

- P_{MAX} = Maximum pressure in kW
- n_{MAX} = round per minute at power P_{MAX}
- TBO = time between two main overhaul, in number of running hours
- $O_{A\ MAX}$ = Motion hours per year
- $O_{P\ MAX}$ = Motion hours per year at P_{MAX}
- Ic Loading index where = $(P_{MEDIA} * O_{A\ MAX})/(P_{MAX} * O_{A\ MIN})$

Where P_{MAX} average power deliverable from the engine in $O_{A\ MAX}$ running hours per year.

The parameters above declared by the Manufacturer are not to be less than the minimum ones provided for the operating profile in [1.6.1].

Engines with Light duty and Medium duty operative profiles are to be type tested in accordance with [1.6.4]. In this respect, Manufacturer is to be admitted to testing and inspections according to an alternative inspection scheme.

The length rolling bearings is to be calculate in accordance with ISO 281-1 referring all the material and lubricating features.

The calculation coefficient Lh10a23 is to refer to the distribution of loads in time provided by the reference operating profile.

The length rolling bearings expressed through the coefficient Lh10a23 is to be in accordance with values listed below:

Light duty:

KA = 1.1

SH = 1.0

SF = 1.1

L h10a23 (following ISO 281-1): >= 5000 hours

Medium Duty:

KA = 1.2

SH = 1.0

SF = 1.2

L h10a23 (following ISO 281-1): >= 5000 hours

1.3.2 Safety coefficient for light and medium duty gears

The shaft of pinions and wheels are to be measured in accordance with [3.4.2]; otherwise a direct calculation contemplating at the same time static and fatigue stresses and assuming the values of safety coefficients may be accepted by the Society:

- Safety coefficient as regards the yield limit = 2,0
- Safety coefficient as regards the alternate bending fatigue limit: = 1,1 (light duty) 1,2 (medium duty)

Gears approved for light duty and medium duty operating profile may reproduce this inscription in the approval documents.

2 Design of gears - Determination of the load capacity

2.1 Symbols, units, definitions

2.1.1 Symbols and units

The meaning of the main symbols used in this Section is specified below.

Other symbols introduced in connection with the definition of influence factors are defined in the appropriate articles.

a : Centre distance, in mm

b : Common face width (for double helix gear, width of one helix), in mm

$b_{1,2}$: Face width of pinion, wheel

d : Reference diameter, in mm

d_a : Tip diameter, in mm

d_b : Base diameter, in mm

d_f : Root diameter, in mm

$d_{w1,2}$: Working diameter of pinion, wheel, in mm

x : Addendum modification coefficient

z : Number of teeth

z_n : Virtual number of teeth

n : Rotational speed, in rpm

U : Reduction ratio

m_n : Normal module, in mm

h : Tooth depth, in mm

α_{Fen} : Pressure angle at the outer point of single tooth pair contact in the normal section

α_n : Normal pressure angle at reference cylinder, in degrees

α_t : Transverse pressure angle at reference cylinder, in degrees

α_{tw} : Transverse pressure angle at working pitch cylinder, in degrees

β : Helix angle at reference cylinder, in degrees

β_b : Base helix angle, in degrees
ε_α : Transverse contact ratio
ε_β : Overlap ratio
ε_γ : Total contact ratio
ρ_{ao} : Tip radius of the tool,
ρ_F : Tooth root radius at the critical section, in mm to be calculated according to the procedure in ISO 6336-3:2019.
h_{Fe} : Bending moment arm for tooth root bending stress for application of load at the outer point of single tooth pair contact, in mm
h_{fp} : Basic rack dedendum, in mm
s_{Fn} : Tooth root normal chord at critical section, in mm
χ_B : Running-in factor (mesh misalignment)
Q : Gearing quality class according to ISO 1328-1:2013
HB : Brinell Hardness
HV : Vickers hardness
R : Minimum tensile strength of gear material, in N/mm^2
$R_{z(f)}$: Mean flank peak-to-valley roughness, in μm (Rz as defined in the reference standard ISO 6336-2:2019)
$R_{z(r)}$: Mean root peak-to-valley roughness, in μm (Rz as defined in the reference standard ISO 6336-2:2019)
F_t : Nominal tangential load, in N
σ_F : Tooth root bending stress, in N/mm^2
σ_{FE} : Endurance limit for tooth root bending stress, in N/mm^2
σ_{FP} : Permissible tooth root bending stress, in N/mm^2
σ_H : Contact stress (Hertzian pressure), in N/mm^2
$\sigma_{H,lim}$: Endurance limit for contact stress (Hertzian pressure), in N/mm^2
σ_{HP} : Permissible contact stress (Hertzian pressure), in N/mm^2
v : Linear velocity at working pitch diameter, in m/s

Subscripts:

- 1 for pinion, i.e. the gear having the smaller number of teeth
- 2 for wheel.

2.1.2 Geometrical definitions

In the calculation of surface durability, b is the common face width on the working pitch diameter.

In tooth strength calculations, b_1, b_2 are the face widths at the respective tooth roots. In any case b_1 and b_2 are not to be taken as greater than b by more than one module (m_n) on either side

For internal gears, z_2 , a, d_2 , d_{a2} , d_{b2} and d_{w2} are to be taken negative.

$$u = \frac{z_2}{z_1}$$

Note 1: u > 0 for external gears, u < 0 for internal gears.

$$\tan\alpha_t = \frac{\tan\alpha_n}{\cos\beta}$$

$$d_{1,2} = \frac{z_{1,2} \cdot m_n}{\cos\beta}$$

$$d_{b_{1,2}} = d_{1,2} \cdot \cos\alpha_t$$

$$d_{w1} = \frac{2a}{u+1}$$

$$d_{w2} = \frac{2au}{u+1}$$

where a = 0,5 (d_{w1} + d_{w2})

$$Z_{n1,2} = \frac{z_{1,2}}{\cos^2\beta_b \cos\beta}$$

$$m_t = \frac{m_n}{\cos\beta}$$

$$\text{inv } \alpha = \tan\alpha - \frac{\Pi\alpha}{180}; \quad \alpha[°]$$

$$\text{inv } \alpha_{tw} = \text{inv } \alpha_t + 2\tan\alpha_n \frac{x_1 + x_2}{z_1 + z_2} \text{ or}$$

$$\cos \alpha_{tw} = \frac{m_t(z_1 + z_2)}{2a} \cos \alpha_t$$

for external gears:

$$\varepsilon_\alpha = \frac{0{,}5 \cdot (d_{a1}^2 - d_{b1}^2)^{\frac{1}{2}} + 0{,}5 \cdot (d_{a2}^2 - d_{b2}^2)^{\frac{1}{2}} - (a \cdot \sin\alpha_{tw})}{\pi \cdot m_t \cdot \cos\alpha_t}$$

for internal gears:

$$\varepsilon_\alpha = \frac{0{,}5 \cdot (d_{a1}^2 - d_{b1}^2)^{\frac{1}{2}} - 0{,}5 \cdot (d_{a2}^2 - d_{b2}^2)^{\frac{1}{2}} - (a \cdot \sin\alpha_{tw})}{\pi \cdot m_t \cdot \cos\alpha_t}$$

$$\varepsilon_\beta = \frac{b \cdot \sin\beta}{\pi \cdot m_n}$$

$$\varepsilon_\gamma = \varepsilon_\alpha + \varepsilon_\beta$$

$$v = \pi d_{1,2} n_{1,2} / 60 \cdot 10^3$$

2.2 Principle

2.2.1

a) The following requirements apply to cylindrical involute spur or helical gears with external or internal teeth, and provide a method for the calculation of the load capacity with regard to:
   - the surface durability (contact stress), and
   - the tooth root bending stress.

   The relevant formulae are provided in [2.4] and [2.5].

   The influence factors common to the formuale are given in [2.3].

b) Gears for which the conditions of validity of some factors or formulae are not satisfied will be given special consideration by the Society.

c) Other methods of determination of load capacity will be given special consideration by the Society.

The nominal tangential load, F_t, tangential to the reference cylinder and perpendicular to the relevant axial plane, is calculated directly from the maximum continuous power transmitted by the gear set by means of the following equations:

$$T_{1,2} = \frac{30 \cdot 10^3 P}{\pi \cdot n_{1,2}}$$

$$F_t = 2000 \cdot T_{1,2} / d_{1,2}$$

2.3 General influence factors

2.3.1 General

General influence factors are defined in [2.3.2], [2.3.3], [2.3.4], [2.3.5] and [2.3.6]. Alternative values may be used provided they are derived from appropriate measurements.

2.3.2 Application factor K_A

The application factor K_A accounts for dynamic overloads from sources external to the gearing.

The values of K_A are given in Tab 3.

Table 3 : Values of K_A

Type of installation			K_A
Main gears (propulsion)	Diesel engine	with hydraulic coupling	1,00
		with elastic coupling	1,30
		with other type of coupling	1,50
	Turbine		1,00
	Electric motor		1,00
Auxiliary gears	Diesel engine	with hydraulic coupling	1,00
		with elastic coupling	1,20
		with other type of coupling	1,40
	Electric motor		1,00

2.3.3 Load sharing factor K_γ

The load sharing factor K_γ accounts for the uneven sharing of load on multiple path transmissions, such as epicyclic gears or dual tandem gears.

The values of K_γ are given in Tab 4.

Table 4 : Values of K_γ

Type of gear		K_γ
Dual tandem gear	without quill shaft **(1)**	1,15
	with quill shaft **(1)**	1,10
Epicyclic gear	with 3 planetary gears and less	1,00
	with 4 planetary gears	1,20
	with 5 planetary gears	1,30
	with 6 planetary gears and more	1,40
(1) A quill shaft is a torsionally flexible shaft intended for improving the load distribution between the gears.		

2.3.4 Dynamic factor K_V

The internal dynamic factor K_V accounts for the additional internal dynamic loads acting on the tooth flanks and due to the vibrations of pinion and wheel.

The values of K_V are given in Tab 5. They apply to cases where all the following conditions are satisfied:

$$\frac{\cdot Z_1}{100}\sqrt{\frac{u^2}{1+u^2}} < 10 m/s$$

- spur gears (b = 0°) and helical gears with b £ 30°
- pinion with relatively low number of teeth, $z_1 < 50$
- solid disc wheels or heavy steel gear rim

and also when

$$\frac{\cdot Z_1}{100}\sqrt{\frac{u^2}{1+u^2}} < 3 m/s$$

in this case it is also applicable to gears having b > 30°.

Table 5 : Values of K_V

Type of gear		K_V	K_2
Spur gear		$K_V = 1 + \left(\frac{K_1}{K_A \frac{F_t}{b}} + K_2 \right) \cdot \frac{v \cdot Z_1}{100} K_3 \sqrt{\frac{u^2}{1 + u^2}}$ where K_1 has the values specified in Tab 6	$K_2 = 0{,}0193$
Helical gear	• if $\varepsilon_\beta \geq 1$:	$K_V = 1 + \left(\frac{K_1}{K_A \frac{F_t}{b}} + K_2 \right) \cdot \frac{v \cdot z_1}{100} K_3 \sqrt{\frac{u^2}{1 + u^2}}$ where K_1 has the values specified in Tab 6	$K_2 = 0{,}0087$
	• if $\varepsilon_\beta < 1$:	$K_V = K_{V\alpha} - \varepsilon_\beta \cdot (K_{V\alpha} - K_{V\beta})$ where K_{Va} is calculated as if the gear were of spur type	

Table 6 : Values of K_1

	ISO grade of accuracy **(1)**					
Type of gear	3	4	5	6	7	8
Spur gear	2,1	3,9	7,5	14,9	26,8	30,1
Helical gear	1,9	3,5	6,7	13,3	23,9	34,8
(1) ISO accuracy grades according to ISO 1328-1:2013. In case of mating gears with different accuracy grades, the grade corresponding to the lower accuracy is to be used.						

For gears other than above, reference is to be made to ISO 6336-1:2019 method B.

Factor K_3 is to be in accordance with the following:

- if

$$\frac{v \cdot z_1}{100} \sqrt{\frac{u^2}{1 + u^2}} \leq 0,2$$

then $K_3 = 2{,}0$

- if

$$\frac{v \cdot z_1}{100} \sqrt{\frac{u^2}{1 + u^2}} > 0,2$$

$$\text{then } K_3 = 2,071 - 0,357 \frac{v \cdot z_1}{100} \sqrt{\frac{u^2}{1 + u^2}}$$

2.3.5 Face load distribution factors $K_{H\beta}$ and $K_{F\beta}$

a) The face load distribution factors, $K_{H\beta}$ for contact stress and $K_{F\beta}$ for tooth root bending stress, account for the effects of non-uniform distribution of load across the face width.

b) The values of $K_{H\beta}$ and $K_{F\beta}$ are to be determined according to method C of ISO 6336-1:2019:

F_m : mean transverse tangential load at the reference circle relevant to mesh calculation,

$$F_m = F_t \cdot K_A \cdot K_V$$

Note 1: The value of $K_{H\beta}$ is to be submitted and documented by the manufacturer of the gears.

c) If the hardest contact is at the end of the face width KFb is:

$K_{F\beta} = K^N_{H\beta}$

$$N = \frac{(b/h)^2}{1 + (b/h) + (b/h)^2}$$

where b/h is the smaller of b_1/h_1 and b_2/h_2 but is not to be taken lower than 3.

For double helical gears, the face width of only one helix is to be used.

d) In case of end relief or crowing: $K_{F\beta} = K_{H\beta}$

2.3.6 Transverse load distribution factors $K_{H\alpha}$ and $K_{F\alpha}$

The transverse load distribution factors, $K_{H\alpha}$ for contact stress, and $K_{F\alpha}$ for tooth root bending stress, account for the effects of pitch and profile errors on the transversal load distribution between two or more pairs of teeth in mesh.

The values of $K_{H\alpha}$ and $K_{F\alpha}$ are to be determined according to Method B of ISO 6336-1:2019.

2.4 Calculation of surface durability

2.4.1 General

The criterion for surface durability is based on the contact stress (Hertzian pressure) on the pitch point or at the inner point of single pair contact.

The contact stress σ_H is not to exceed the permissible contact stress σ_{HP}.

2.4.2 Contact stress σ_H (1/1/2015)

The contact stress σ_H is to be determined as follows.

- for the pinion

$$\sigma_H = Z_B \cdot \sigma_{H0} \sqrt{K_A \cdot K_\gamma \cdot K_V \cdot K_{H\beta} \cdot K_{H\alpha}}$$

- for the wheel

$$\sigma_H = Z_D \cdot \sigma_{H0} \sqrt{K_A \cdot K_\gamma \cdot K_V \cdot K_{H\beta} \cdot K_{H\alpha}}$$

where:

σ_{H0} : calculated from the following formulae:

for external gears:

$$\sigma_{H0} = Z_H \cdot Z_E \cdot Z_\varepsilon \cdot Z_\beta \sqrt{\frac{F_t}{d_1 \cdot b} \cdot \frac{u+1}{u}}$$

for internal gears:

$$\sigma_{H0} = Z_H \cdot Z_E \cdot Z_\varepsilon \cdot Z_\beta \sqrt{\frac{F_t}{d_1 \cdot b} \cdot \frac{u-1}{u}}$$

K_A : Application factor (see [2.3.2]),

K_γ : Load sharing factor (see [2.3.3]),

K_V : Dynamic factor (see [2.3.4]),

$K_{H\beta}$: Face load distribution factors (see [2.3.5]),

$K_{H\alpha}$: Transverse load distribution factors (see [2.3.6]),

Z_B : Single pair tooth contact factor for pinion (see [2.4.4]),

Z_D : Single pair tooth contact factor for wheel (see [2.4.4]),

Z_H : Zone factor (see [2.4.5]),

Z_E : Elasticity factor (see [2.4.6]),

Z_ε : Contact ratio factor (see [2.4.7]),

Z_β : Helix angle factor (see [2.4.8]).

2.4.3 Permissible contact stress σ_{HP}

The permissible contact stress σ_{HP} is to be determined separately for pinion and wheel using the following formula:

$$\sigma_{HP} = \frac{\sigma_{H,lim}}{S_H} \cdot Z_L \cdot Z_V \cdot Z_R \cdot Z_W \cdot Z_X \cdot Z_N$$

where:

Z_L : Lubricant factor (see [2.4.9]),

Z_V : Velocity factor (see [2.4.9]),

Z_R : Roughness factor (see [2.4.9]),

Z_W : Hardness ratio factor (see [2.4.10]),

Z_X : Size factor for contact stress (see [2.4.11]),

Z_N : :Life factor for contact stress is to be determined according to method B of ISO 6336-2:2019, or assumed to be 1,

S_H : Safety factor for contact stress (see [2.4.12]).

2.4.4 Single pair tooth contact factors Z_B and Z_D

The single pair tooth contact factors Z_B for pinion and Z_D for wheel account for the influence of the tooth flank curvature on contact stresses at the inner point of single pair contact in relation to Z_H. These factors transform the contact stress determined at the pitch point to contact stresses considering the flank curvature at the inner point of single pair contact.

Z_B and Z_D are to be determined as follows:

a) for spur gears ($\varepsilon_\beta = 0$):

- $Z_B = M_1$ or 1, whichever is the greater, where

$$M_1 = \frac{\tan\alpha_{tw}}{\sqrt{\left[\sqrt{\left(\frac{d_{a1}}{d_{b1}}\right)^2 - 1} - \frac{2\pi}{z_1}\right] \cdot \left[\sqrt{\left(\frac{d_{a2}}{d_{b2}}\right)^2 - 1} - (\varepsilon_\alpha - 1)\frac{2\pi}{z_2}\right]}}$$

- $Z_D = M_2$ or 1, whichever is the greater, where

$$M_2 = \frac{\tan\alpha_{tw}}{\sqrt{\left[\sqrt{\left(\frac{d_{a2}}{d_{b2}}\right)^2 - 1} - \frac{2\pi}{z_2}\right] \cdot \left[\sqrt{\left(\frac{d_{a1}}{d_{b1}}\right)^2 - 1} - (\varepsilon_\alpha - 1)\frac{2\pi}{z_1}\right]}}$$

b) for helical gears:

- with $\varepsilon_\beta \geq 1$: $Z_B = Z_D = 1$.
- with $\varepsilon_\beta < 1$: Z_B and Z_D are to be determined by linear interpolation between:
  - Z_B and Z_D for spur gears, and
  - Z_B and Z_D for helical gears with $\varepsilon_\beta \geq 1$,

  thus
  - $Z_B = M_1 - \varepsilon_\beta (M_1 - 1)$ and $Z_B \geq 1$
  - $Z_D = M_2 - \varepsilon_\beta (M_2 - 1)$ and $Z_D \geq 1$

For internal gears, Z_D is to be taken as 1,0.

2.4.5 Zone factor Z_H

The zone factor Z_H accounts for the influence on the Hertzian pressure of tooth flank curvature at the pitch point and transforms the tangential load at the reference cylinder to normal load at the pitch cylinder.

Z_H is to be determined as follows:

$$Z_H = \sqrt{\frac{2 \cdot \cos\beta_b \cdot \cos\alpha_{tw}}{(\cos\alpha_t)^2 \cdot \sin\alpha_{tw}}}$$

2.4.6 Elasticity factor Z_E

The elasticity factor Z_E accounts for the influence of the metal properties (module of elasticity E and Poisson's ratio ν) on the Hertzian pressure.

For steel gears, $Z_E = 189{,}8\ N^{1/2}/mm$.

In other cases, reference is to be made to ISO 6336-2:2019.

2.4.7 Contact ratio factor Z_ε

The contact ratio factor Z_ε accounts for the influence of the transverse contact ratio and the overlap ratio on the specific surface load of gears.

Z_ε is to be determined as follows:

a) for spur gears:

$$Z_\varepsilon = \sqrt{\frac{4 - \varepsilon_\alpha}{3}}$$

b) for helical gears:

- for $\varepsilon_\beta < 1$

$$Z_\varepsilon = \sqrt{\frac{4 - \varepsilon_\alpha}{3} \cdot (1 - \varepsilon_\beta) + \frac{\varepsilon_\beta}{\varepsilon_\alpha}}$$

- for $\varepsilon_\beta \geq 1$

$$Z_\varepsilon = \sqrt{\frac{1}{\varepsilon_\alpha}}$$

2.4.8 Helix angle factor Z_β

The helix angle factor Z_β accounts for the influence of helix angle on surface durability, allowing for such variables as the distribution of load along the lines of contact.

Z_β is to be determined as follows:

$$Z_\beta = \sqrt{\frac{1}{\cos\beta}}$$

2.4.9 Lubrication, speed and roughness factors Z_L , Z_V and Z_R

The lubricant factor Z_L accounts for the influence of the type of the lubricant and of its viscosity. The velocity factor Z_V accounts for the influence of the pitch line velocity. The roughness factor Z_R accounts for the influence of the surface roughness on the surface endurance capacity.

The factors are to be determined for the softer material where gear pairs are of different hardness.

These factors are to be determined as follows:

a) Lubricant factor Z_L

$$Z_L = C_{ZL} + \frac{4 \cdot (1{,}0 - C_{ZL})}{\left(1{,}2 + \frac{134}{\nu_{40}}\right)^2}$$

where:

ν_{40} : nominal kinematic viscosity of the oil at 40°C, mm^2/s

C_{ZL} :
- for $\sigma_{H,lim} < 850$ N/mm²

  $C_{ZL} = 0{,}83$
- for 850 N/mm² $\leq \sigma_{H,lim} \leq$ 1200 N/mm²

$$C_{ZL} = 0{,}08\left(\frac{\sigma_{H,lim} - 850}{305}\right) + 0{,}83$$

- for $\sigma_{H,lim} > 1200$ N/mm²

  $C_{ZL} = 0{,}91$

b) Velocity factor Z_V

$$Z_V = C_{ZV} + \frac{2 \cdot (1{,}0 - C_{ZV})}{\sqrt{0{,}8 + \frac{32}{v}}}$$

where:

- for $\sigma_{H,lim}$ < 850 N/mm²
  C_{ZV} = 0,85
- for 850 N/mm² ≤ $\sigma_{H,lim}$ ≤ 1200 N/mm²

$$C_{ZV} = C_{ZL} + 0,02$$

- for $\sigma_{H,lim}$ > 1200 N/mm²
  C_{ZV} = 0,93

c) Roughness factor Z_R

$$Z_R = \left(\frac{3}{R_{Z10(f)}}\right)^{C_{ZR}}$$

where:

$R_{Z10(f)}$: Mean relative flank peak-to-valley roughness for the gear pair

$$R_{Z10(f)} = R_{Z(f)} \sqrt[3]{\frac{10}{\rho_{red}}}$$

$R_{Z(f)}$: Mean flank peak-to-valley roughness of the gear pair,

$$R_{Z(f)} = \frac{R_{Z(f)1} + R_{Z(f)2}}{2}$$

where Rz(f)1 and Rz(f)2 are mean values measured on several tooth flanks

ρ_{red} : Relative radius of curvature, equal to:

$$\rho_{red} = \frac{\rho_1 \cdot \rho_2}{\rho_1 + \rho_2} \quad \text{with:}$$

$$\rho_1 = 0,5 \cdot d_{b1} \cdot \tan\alpha_{tw}$$

$$\rho_2 = 0,5 \cdot d_{b2} \cdot \tan\alpha_{tw}$$

d_b being taken negative for internal gears,

If the roughness stated is an arithmetic mean roughness, i.e. R_a value (=CLA value) (=AA value) the following approximate relation may be applied:

R_a = CLA = AA = R_z / 6

C_{ZR} : Coefficient having the following values:

- for $\sigma_{H,lim}$ < 850 N/mm²
  C_{ZR} = 0,15
- for 850 N/mm² ≤ $\sigma_{H,lim}$ ≤ 1200 N/mm²

$$C_{ZR} = 0,32 - \frac{\sigma_{H,lim}}{5000}$$

- for $\sigma_{H,lim}$ > 1200 N/mm²
  C_{ZR} = 0,08

2.4.10 Hardness ratio factor Z_W (1/1/2015)

The hardness ratio factor Z_W accounts for the increase of surface durability in the case of a soft steel gear meshing with a significantly (≥ 200HV) harder gear with a smooth surface in the following cases:

a) Surface-hardened pinion with through-hardened wheel

- for HB < 130

$$Z_W = 1,2 \cdot \left(\frac{3}{R_{ZH}}\right)^{0,15}$$

- for 130 ≤ HB ≤ 470

$$Z_W = \left(1,2 - \frac{HB - 130}{1700}\right) \cdot \left(\frac{3}{R_{ZH}}\right)^{0,15}$$

- for HB > 470

$$Z_W = \left(\frac{3}{R_{ZH}}\right)^{0,15}$$

where:

HB : Brinell hardness of the tooth flanks of the softer gear of the pair

R_{zH} : equivalent roughness, mm

$$R_{ZH} = \frac{R_{Z1} \cdot (10/\rho_{red})^{0,33} \cdot (R_{Z1}/R_{Z2})^{0,66}}{(V \cdot \nu_{40}/1500)^{0,33}}$$

r_{red} : relative radius of curvature

b) Through-hardened pinion and wheel

When the pinion is substantially harder than the wheel, the work hardening effect increases the load capacity of the wheel flanks. Z_W applies to the wheel only, not to the pinion.

- If HB_1 / HB_2 < 1,2

  Z_W = 1

- if 1,2 £ HB_1 / HB_2 £ 1,7

$$Z_W = 1 + \left(0,00898\frac{HB_1}{HB_2} - 0,00829\right) \cdot (u - 1)$$

- if HB_1 / HB_2 > 1,7

$$Z_W = 1 + 0,00698 \cdot (u - 1)$$

If gear ratio u > 20 then the value u = 20 is to be used.

In any case, if calculated Z_W <1 then the value Z_W = 1,0 is to be used.

2.4.11 Size factor Z_X

The size factor Z_X accounts for the influence of tooth dimensions on permissible contact stress and reflects the non-uniformity of material properties.

Z_X is to be determined as follows:

- for through-hardened steel: Z_X = 1
- for nitrided or nitrocarburised steel:

  Z_X = 1,08 - 0,011 m_n with $0,75 \le Z_X \le 1$
- for case-hardened steels:

  Z_X = 1,05 - 0,005 m_n with $0,90 \le Z_X \le 1$

2.4.12 Safety factor for contact stress S_H

The values to be adopted for the safety factor for contact stress S_H are given in Tab 7.

Table 7 : Safety factor for contact stress S_H

Type of installation		S_H
Main gears (propulsion)	single machinery	1,25
	duplicate machinery	1,20
Auxiliary gears		1,15

2.4.13 Endurance limit for contact stress $\sigma_{H,lim}$

The endurance limit for contact stress $\sigma_{H,lim}$ is the limit of repeated contact stress which can be permanently endured.

The endurance limit for contact stress $\sigma_{H,lim}$ is to be determined, in general, making reference to values indicated in the standard ISO 6336-5:2016, for material quality MQ or as given in Tab 8 in relation to the type of steel employed and the heat treatment performed.

Table 8 : Endurance limit for contact stress $\sigma_{H,lim}$

Type of steel and heat treatment	$\sigma_{H,lim}$ in N/mm^2
through-hardened carbon steels	0,26 R + 350
through-hardened alloy steels	0,42 R + 330
case-hardened alloy steels	1500
nitrided (nitriding steels)	1250
nitrided or induction-hardened (other steels)	1000

2.5 Calculation of tooth bending strength

2.5.1 General

The criterion for tooth bending strength is the permissible limit of local tensile stress in the root fillet.

The root stress σ_F is not to exceed the permissible tooth root bending stress σ_{FP}.

The root stress σ_F and the permissible root stress σ_{FP} are to be calculated separately for the pinion and the wheel.

The result of rating calculations made by following this method are acceptable for normal pressure angles up to 25° and reference helix angles up to 30°.

For larger pressure angles and large helix angles, the calculated results should be confirmed by experience as by Method A of the reference standard ISO 6336-3:2019.

2.5.2 Tooth root bending stress σ_F

The tooth root bending stress σ_F is to be determined as follows:

$$\sigma_F = \frac{F_t}{b \cdot m_n} \cdot Y_F \cdot Y_S \cdot Y_\beta \cdot Y_B \cdot Y_{DT} \cdot K_A \cdot K_\gamma \cdot K_V \cdot K_{F\beta} \cdot K_{F\alpha} \le \sigma_{FP}$$

where:

Y_F : Tooth form factor (see [2.5.4])

Y_S : Stress correction factor (see [2.5.5])

Y_β : Helix factor (see [2.5.6])

Y_B : Rim thickness factor (see [2.5.7]).

Y_{DT} : Deep tooth factor (see [2.5.8]).

K_A : Application factor (see [2.3.2])

K_γ : Load sharing factor (see [2.3.3])

K_V : Dynamic factor (see [2.3.4])

$K_{F\beta}$: Face load distribution factor (see [2.3.5])

$K_{F\alpha}$: Transverse load distribution factor (see [2.3.6]).

2.5.3 Permissible tooth root bending stress σ_{FP}

The permissible tooth root bending stress σ_{FP} is to be determined separately for pinion and wheel using the following formula:

$$\sigma_{FP} = \frac{\sigma_{FE} \cdot Y_d \cdot Y_N}{S_F} \cdot (Y_{\delta relT} \cdot Y_{RrelT} \cdot Y_X)$$

where:

σ_{FE} : Endurance limit for tooth root bending stress (see [2.5.9])

Y_d : Design factor (see [2.5.10])

Y_N : Life factor for bending stress (see [2.5.11])

$Y_{\delta relT}$: Relative notch sensitive factor (see [2.5.12])

Y_{RrelT} : Relative surface factor (see [2.5.13])

Y_X : Size factor (see [2.5.14])
S_F : Safety factor for tooth root bending stress (see [2.5.15]).

2.5.4 Tooth form factor Y_F

The tooth form factor Y_F takes into account the effect of the tooth form on the nominal bending stress assuming the load applied at the outer point of a single pair tooth contact.

In the case of helical gears, the form factors are to be determined in the normal section, i.e. for the virtual spur gear with the virtual number of teeth z_n.

Y_F is to be determined separately for the pinion and the wheel using the following formula:

$$Y_F = \frac{6 \cdot \frac{h_{Fe}}{m_n} \cdot \cos\alpha_{Fen}}{\left(\frac{s_{Fn}}{m_n}\right)^2 \cdot \cos\alpha_n}$$

where h_{Fe}, α_{Fen} and s_{Fn} are shown in Fig 1.

The parameters required for the calculation of Y_F are to be determined according to Method B of ISO 6336-3:2019.

2.5.5 Stress correction factor Y_S

The stress correction factor Y_S is used to convert the nominal bending stress.

Y_S is to be determined separately for the pinion and for the wheel.

Y_S is to be determined as follows:

$$Y_S = (1{,}2 + 0{,}13L) \cdot q_s^{\left(\frac{1}{1{,}21 + (2{,}3/L)}\right)}$$

where:

- $L = \frac{s_{Fn}}{h_{Fe}}$

  s_{Fn} and h_{Fe} are taken from [2.5.4]
- the notch parameter q_S as defined in [2.5.12] is assumed to be within the range $1 \le q_s < 8$.

2.5.6 Helix angle factor Y_β

The helix angle factor Y_β converts the tooth root stress of a virtual spur gear to that of the corresponding helical gear, taking into account the oblique orientation of the lines of mesh contact.

Y_β is to be determined as follows:

- for $\varepsilon_\beta < 1$:

  $Y_\beta = 1 - \varepsilon_\beta (\beta/120)$
- for $\varepsilon_\beta > 1$:

  $Y_\beta = 1 - \beta/120$

Where $\beta > 30°$, the value $\beta = 30°$ is to be substituted for β in the above formulae.

2.5.7 Rim thickness factor Y_B

The rim thickness factor Y_B is a simplified factor used to de-rate thin rimmed gears. For critically loaded applications, this method should be replaced by a more comprehensive analysis.

Factor Y_B is to be determined as follows:

a) for external gears:

- If $s_R / h > 1{,}2$

  $Y_B = 1$
- if $0{,}5 < s_R / h < 1{,}2$

  $$Y_B = 1{,}6 \cdot \ln\left(2{,}242 \frac{h}{s_R}\right)$$

  where:

s_R : Rim thickness of external gears, mm
h : Tooth height, mm
The case s_R / h £ 5,0 is to be avoided.

b) for internal gears:

- If $s_R / m_n > 3,5$

  $Y_B = 1$

- if $1,75 < s_R / m_n < 3,5$

$$Y_B = 1,15 \cdot \ln\left(8,324 \frac{m_n}{s_R}\right)$$

where:

s_R : Rim thickness of internal gears, mm
The case $s_R / m_n \le 1,75$ is to be avoided.

2.5.8 Deep tooth factor Y_{DT}

The deep tooth factor Y_{DT} adjusts the tooth root stress to take into account high precision gears and contact ratios within the range of virtual contact ratio $2,05 \le \varepsilon_{\alpha n} \le 2,5$, where:

$$\varepsilon_{\alpha n} = \frac{\varepsilon_\alpha}{\cos^2\beta_b}$$

Factor Y_{DT} is to be determined as follows:

- if ISO accuracy grade ≤ 4 and $\varepsilon_{\alpha n} > 2,5$

  $Y_{DT} = 0,7$

- if ISO accuracy grade ≤ 4 and $2,05 \le \varepsilon_{\alpha n} \le 2,5$

  $Y_{DT} = 2,366 - 0,666\ \varepsilon n$

- in all other cases

  $Y_{DT} = 1,0$

2.5.9 Endurance limit for tooth root bending stress σ_{FE}

The endurance limit for tooth root bending stress σ_{FE} is the local tooth root bending stress which can be permanently endured.

The bending endurance limit is to be determined, in general, according to ISO 6336-5:2016, for material quality MQ or as given in Tab 9 in relation to the type of steel employed.

Figure 1 : Geometric elements of teeth

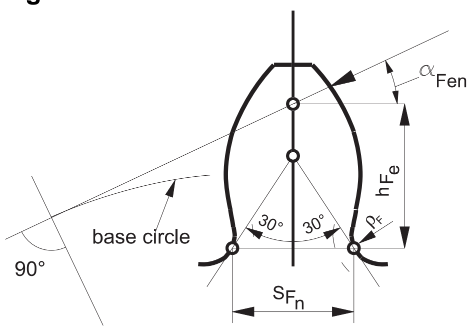


Table 9 : Values of endurance limit for tooth root bending stress σ_{FE}

Type of steel	σ_{FE}, in N/mm²
Through-hardened carbon steel	0,17 R + 300 **(1)**
Through-hardened alloy steel	0,22 R + 340 **(1)**
Surface-hardened by means of flame or induction hardening	0,66 HV + 270
(1) In case of shot peened tooth root the given value can be increased up to 20% for case hardened steels and up to 10% for through hardened steels.	

Type of steel	σ_{FE}, in N/mm²
Nitriding steel, surface-hardened by means of gas nitriding	740
Alloy steels, surface-hardened by means of bath or gas nitriding	640 **(1)**
Case-hardened steels	840 **(1)**
(1) In case of shot peened tooth root the given value can be increased up to 20% for case hardened steels and up to 10% for through hardened steels.	

2.5.10 Design factor Y_d

The design factor Y_d takes into account the influence of load reversing and shrinkfit prestressing on the tooth root strength.

Y_d is to be determined as follows:

$$Y_d = Y_{dr} \cdot Y_{ds}$$

- for gears with occasional part load in reverse direction, such as main wheel in reverse gearboxes: $Y_{dr} = 0,9$
- for idler gears: $Y_{dr} = 0,7$
- otherwise $Y_{dr} = 1$
- for shrunk on pinions and wheel rims:

  $$Y_{ds} = 1 - \frac{\sigma_t}{\sigma_{FE}}$$

  where:

  σ_t : shrinkage induced tangential stress in way of the tooth root.
- otherwise: $Y_{ds} = 1$

2.5.11 Life factor for bending stress Y_N

The life factor for bending stress Y_N accounts for the higher tooth root bending stress permissible if a limited life (number of cycles) is required.

Y_N assumed equal to Y_{NT} according to method B ISO 6336-3:2019 or assumed to be as follows:

- for gears intended for ahead running: $Y_N = 1$
- for gear intended for astern running only: $Y_N = 1,25$
- for other intermittent running, Y_N will be specially considered by the Society.

2.5.12 Relative notch sensitivity factor $Y_{\delta rel\,T}$

The relative notch sensitivity factor $Y_{\delta rel\,T}$ indicates the extent to which the theorically concentrated stress lies above the fatigue endurance limit.

$Y_{\delta rel\,T}$ is to be determined as follows:

$$Y_{\delta relT} = \frac{1 + \sqrt{0,2\rho'(1 + 2q_s)}}{1 + \sqrt{1,2\rho'}}$$

where:

$$q_s = \frac{s_{Fn}}{2 \cdot \rho_F}$$

q_s : notch parameter

r' : slip-layer thickness, mm, taken from Tab 10

Table 10

Material	r', in mm
Case hardened steels, flame or induction hardned steels	0,0030
through hardened steels **(1)**, yield point R_e = 500 N/mm^2 600 N/mm^2 800 N/mm^2 1000 N/mm^2	 0,0281 0,0194 0,0064 0,0014
nitrided steels	0,1005
(1) The given values of r' can be interpolated for values of R_e not stated above	

2.5.13 Relative surface factor $Y_{Rrel\ T}$

The relative surface factor $Y_{Rrel\ T}$, takes into account the dependence of the root strength on the surface condition on the tooth root fillet, mainly the dependence on the peak to valley surface roughness.

The values to be adopted for $Y_{Rrel\ T}$ are given in Tab 11 in relation to the type of steel employed. They are valid only when scratches or similar defects deeper than 2 R_Z are not present.

Table 11 : Values of relative surface factor $Y_{Rrel\ T}$

Material	$R_Z < 1$	$1 \le R_Z \le 40$
Case-hardened steels, through-hardened steels (s_B > 800 N/mm^2)	1,120	$1{,}674 - 0{,}529\ (R_Z+1)^{0,1}$
Normalised steels (s_B < 800 N/mm^2)	1,070	$5{,}306 - 4{,}203\ (R_Z+1)^{0,01}$
Nitrided steels	1,025	$4{,}299 - 3{,}259\ (R_Z+1)^{0,0058}$

2.5.14 Size factor Y_X

The size factor Y_X takes into account the decrease of the strength with increasing size.

The values to be adopted for Y_X are given in Tab 12 in relation to the type of steel employed and the value of the normal module m_n.

Table 12 : Values of size factor Y_X

Type of steel	Normal module	Value of Y_X
All types of steel	$m_n \le 5$	1
Normalised through-hardened	$5 < m_n < 30$	$1{,}03 - 0{,}006\ m_n$
	$m_n \ge 30$	0,85
Surface-hardened steels	$5 < m_n < 25$	$1{,}05 - 0{,}01\ m_n$
	$m_n \ge 25$	0,80

2.5.15 Safety factor for tooth root bending stress S_F

The values to be adopted for the safety factor for tooth root bending stress S_F are given in Tab 13.

Table 13 : Values of safety factor for tooth root bending stress S_F

Type of installation		S_F
Main gears (propulsion)	single machinery	1,55
	duplicate machinery	1,4

Type of installation		S_F
Auxiliary gears	single machinery	1,4
	duplicate machinery	1,3

3 Design and construction - except tooth load capacity

3.1 Materials

3.1.1 General

a) Forged, rolled and cast materials used in the manufacturing of shafts, couplings, pinions and wheels are to comply with the requirements of Part D.

b) Materials other than steels will be given special consideration by the Society.

3.1.2 Steels for pinions and wheel rims

a) Steels intended for pinions and wheels are to be selected considering their compatibility in service. In particular, for through-hardened pinion / wheel pairs, the hardness of the pinion teeth is to exceed that of the corresponding wheel. For this purpose, the minimum tensile strength of the pinion material is to exceed that of the wheel by at least 15 %.

b) The minimum tensile strength of the core is not to be less than:

- 750 N/mm^2 for case-hardened teeth
- 800 N/mm^2 for induction-hardened or nitrided teeth

3.2 Teeth

3.2.1 Manufacturing accuracy

a) The standard of accuracy of teeth of propulsion machinery gearing transmitting a power of 1000 kW and above is to correspond to that of quality class 4 as defined by ISO 1328-1:2013.

b) The standard of accuracy of teeth of propulsion machinery gearing transmitting a power lower than 1000 kW is to correspond to that of quality class 6 as defined by ISO 1328-1:2013.

c) A lower standard of accuracy (i.e. higher ISO quality classes) may be accepted for auxiliary machinery gearing and for particular cases of propulsion machinery gearing, subject to special consideration.

d) Mean roughness (peak-to-valley) of shaved or ground teeth is not to exceed 4 μm.

e) Wheels are to be cut by cutters with a method suitable for the expected type and quality. Whenever necessary, the cutting is to be carried out in a temperature-controlled environment.

3.2.2 Tooth root

Teeth are to be well faired and rounded at the root. The fillet radius at the root of the teeth, within a plane normal to the teeth, is to be not less than 0,25 m_n.

Profile-grinding of gear teeth is to be performed in such a way that no notches are left in the fillet.

3.2.3 Tooth tips and ends

a) All sharp edges on the tips and ends of gear teeth are to be removed after cutting and finishing of teeth.

b) Where the ratio b/d exceeds 0,3, the ends of pinion and wheel are to be chamfered to an angle between 45 and 60 degrees. The chamfering depth is to be at least equal to 1,5 m_n.

3.2.4 Surface treatment

a) The hardened layer on surface-hardened gear teeth is to be uniform and extended over the whole tooth flank and fillet.

b) Where the pinions and the toothed portions of the wheels are case-hardened and tempered, the teeth flanks are to be ground while the bottom lands of the teeth remain only case-hardened. The superficial hardness of the case-hardened zone is to be at least equal to 56 C Rockwell units.

c) Where the pinions and the toothed portions of the wheels are nitrided, the hardened layer is to comply with Tab 14.

d) The use of other processes of superficial hardening of the teeth, such as flame hardening, will be given special consideration, in particular as regards the values to be adopted for $\sigma_{H,lim}$ and σ_{FE}.

Table 14 : Characteristics of the hardened layer for nitrided gears

Type of steel	Minimum thickness of hardened layer (mm) **(1)**	Minimum hardness (HV)
Nitriding steel	0,6	500 (at 0,25 mm depth)
Other steels	0,3	450 (surface)
(1) Depth of the hardened layer to core hardness. When the grinding of nitrided teeth is performed, the depth of the hardened layer to be taken into account is the depth after grinding.		

3.3 Wheels and pinions

3.3.1 General

Wheel bodies are to be so designed that radial deflexions and distorsions under load are prevented, so as to ensure a satisfactory meshing of teeth.

3.3.2 Welding

a) Where welding is employed for the construction of wheels, the welding procedure is to be submitted to the Society for approval. Welding processes and their qualification are to comply with Part D.

b) Stress relieving treatment is to be performed after welding.

c) Examination of the welded joints is to be performed by means of magnetic particle or dye penetrant tests to the satisfaction of the Surveyor. Suitable arrangements are to be made to permit the examination of the internal side of the welded joints.

3.3.3 Shrink-fits

The shrink assembly of:

- rim and wheel body
- wheel body and shaft

is to be designed according to Sec 7.

3.3.4 Bolting

The bolting assembly of:

- rim and wheel body
- wheel body and shaft

is to be designed according to Sec 7.

The nuts are to be suitably locked by means other than welding.

3.4 Shafts and bearings

3.4.1 General

Shafts and their connections, in particular flange couplings and shrink-fits connections, are to comply with the provisions of Sec 7.

3.4.2 Pinion and wheel shafts

The minimum diameter of pinion and gear wheel shafts is not to be less than the value d_S, in mm, given by the following formula:

$$d_S = \left\{ \left[\left(10,2 + \frac{28000}{R_{S,min}} \right) T \right]^2 + \left[\frac{170000}{412 + R_{s,min}} M \right]^2 \right\}^{\frac{1}{6}} \left(\frac{1}{1 - K_d^{\,4}} \right)^{\frac{1}{3}}$$

where:

$R_{S,min}$: minimum yield strength of the shaft material, in N/mm^2

T : nominal torque transmitted by the shaft, in Nm

M : bending moment on the shaft, in Nm

K_d : coefficient having the following values:

- for solid shafts: $K_d = 0$
- for hollow shafts, K_d is equal to the ratio of the hole diameter to the outer shaft diameter.
  Where $K_d \le 0,3$: $K_d = 0$ may be taken.

Note 1: The values of d_S, T and M refer to the cross-section of the shaft concerned.

Note 2: In correspondence of keyways d_S shall be increased by 10%.

As an alternative to the above given formula, the Society may accept direct strength calculations showing that the equivalent stress represented in a diagram alternate stress/average stress falls below the lines defined by the points having coordinates:

$$(R_m;0), (0;\sigma_{fa}/1,5)$$

and

$$(0,8R_s;0), (0;0,8R_s)$$

where σ_{fa} is the pure alternate bending fatigue limit for a survival probability not less than 80%.

3.4.3 Quill shafts

The minimum diameter of quill shafts subject to torque only is not to be less than the value d_{QS}, in mm, given by the following formula:

$$d_{QS} = \left[\left(7,65 + \frac{27000}{R_{S,min}}\right) \cdot \frac{T}{1 - K_d^{\,4}}\right]^{\frac{1}{3}}$$

$R_{S,min}$ and K_d being defined in [3.4.2].

3.4.4 Bearings

a) Thrust bearings and their supports are to be so designed as to avoid detrimental deflexions under load.

b) Life duration of bearings L_{10h} calculated according to ISO 281-1, is not be less than 40000 hours. Shorter durations may be accepted on the basis of the actual load time distribution, and subject to the agreement of the owner.

3.5 Casings

3.5.1 General

Gear casings are to be of sufficient stiffness such that misalignment, external loads and thermal effects in all service conditions do not adversely affect the overall tooth contact.

3.5.2 Welded casings

a) Carbon content of steels used for the construction of welded casings is to comply with the provisions of Part D.

b) The welded joints are to be so arranged that welding and inspection can be performed satisfactorily. They are to be of the full penetration type.

c) Welded casings are to be stress-relieved after welding.

3.5.3 Openings

Access or inspection openings of sufficient size are to be provided to permit the examination of the teeth and the structure of the wheels.

3.6 Lubrication and clutch control

3.6.1 General

a) Manufacturers are to take care of the following points :
   - reliable lubrication of gear meshes and bearings is ensured :
     - over the whole speed range, including starting, stopping and, where applicable, manoeuvring
     - for all angles stated in Sec 1, [2.4]
   - in multi-propellers plants not fitted with shaft brakes, provision is to be made to ensure lubrication of gears likely to be affected by windmilling.

b) Lubrication by means other than oil circulation under pressure will be given special consideration.

3.6.2 Pumps

a) Gears intended for propulsion or other essential services are to be provided with:

   1) one main lubricating pump, capable of maintaining a sufficient lubrication of the gearbox in the whole speed range

   2) and one standby pump independently driven of at least the same capacity.

   3) an additional standby pump to the one required above, in case the failure of any pump prevents the propulsion from starting.

b) In the case of:

   1) gears having a transmitted power not exceeding 375 kW

   2) or multi-engines plants,

   one of the pumps mentioned in a) may be a spare pump ready to be connected to the reduction gear lubricating oil system, provided disassembling and reassembling operations can be carried out on board in a short time.

c) The requirements in a) 1), a) 2) and b) 1), b) 2) also apply to clutch control oil supply pumps.

   With reference to the requirements in a) 1) and a) 2), in case the failure of any pump prevents the operation of the clutch, an additional stand-by pump is to be fitted.

3.6.3 Filtration

a) Forced lubrication systems are to be fitted with a device which efficiently filters the oil in the circuit.

b) When fitted to gears intended for propulsion machinery or machinery driving electric propulsion generators, such filters are to be so arranged that they can be easily cleaned without stopping the lubrication of the machines.

3.7 Control and monitoring

3.7.1

In addition to those of this item [3.7], the general requirements given in Chapter 3 apply.

In the case of s with automation notations, the requirements in Part F, Chapter 3 also apply.

3.7.2

Gears are to be provided with the alarms and safeguards listed in Tab 15.

Note 1: Some departures from Tab 15 may be accepted by the Society in the case of s with a restricted navigation notation.

4 Installation

4.1 General

4.1.1 Manufacturers and yards are to take care directly that stiffness of gear seating and alignment conditions of gears are such as not to adversely affect the overall tooth contact and the bearing loads under all operating conditions of the .

4.2 Fitting of gears

4.2.1 Means such as stoppers or fitted bolts are to be arranged in the case of gears subject to propeller thrust. However, where the thrust is transmitted by friction and the relevant safety factor is not less than 2, such means may be omitted.

5 Certification, inspection and testing

5.1 General

5.1.1

a) Inspection and testing of shafts and their connections (flange couplings, hubs, bolts, pins) are to be carried out in accordance with the provisions of Sec 7.

b) For inspection of welded joints of wheels, refer to [3.3.2].

5.2 Workshop inspection and testing

5.2.1 Testing of materials

Chemical composition and mechanical properties are to be tested in accordance with the applicable requirements of Pt D, Ch 2, Sec 3 for the following items:

- pinions and wheel bodies
- rims
- plates and other elements intended for propulsion gear casings of welded construction.

5.2.2 Testing of pinion and wheel forgings

a) Mechanical tests of pinions and wheels are to be carried out in accordance with:
   - Pt D, Ch 2, Sec 3, [5.6] for normalised and tempered or quenched and tempered forgings
   - Pt D, Ch 2, Sec 3, [5.7] for surface-hardened forgings.

b) Non-destructive examination of pinion and wheel forgings is to be performed in accordance with Pt D, Ch 2, Sec 3, [5.8].

5.2.3 Balancing test

Rotating components, in particular gear wheel and pinion shaft assemblies with the coupling part attached, are to undergo a static balancing test.

Where $n^2.d \geq 1,5.10^9$, gear wheel and pinion shaft assemblies are also to undergo a dynamic balancing test.

5.2.4 Verification of cutting accuracy

Examination of the accuracy of tooth cutting is to be performed in the presence of the Surveyor. Records of measurements of errors, tolerances and clearances of teeth are to be submitted at the request of the Surveyor.

5.2.5 Meshing test

a) A tooth meshing test is to be performed in the presence of the Surveyor. This test is to be carried out at a load sufficient to ensure tooth contact, with the journals located in the bearings according to the normal running conditions. Before the test, the tooth surface is to be coated with a thin layer of suitable coloured compound.

b) The results of such test are to demonstrate that the tooth contact is adequately distributed on the length of the teeth. Strong contact marks at the end of the teeth are not acceptable.

c) A permanent record of the tooth contact is to be made for the purpose of subsequent checking of alignment following installation on board.

5.2.6 Hydrostatic tests

a) Hydraulic or pneumatic clutches are to be hydrostatically tested before assembly to 1,5 times the maximum working pressure of the pumps.

b) Pressure piping, pumps casings, valves and other fittings are to be hydrostatically tested in accordance with the requirements of Sec 10, [21].

Table 15 : Reduction gears / reversing gears and clutch monitoring

Symbol convention H = High, HH = High High, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Main Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Lubricating oil temperature		local					
Lubricating oil pressure		local					
	L						
Oil tank level		local					
Clutch control oil pressure	L						

5.3 Type approved gearing

5.3.1 Issue of Tasneef Type Approval Certificate

In some cases in accordance with Pt A, Ch 2, App 3 the gearing defined in [1.1.1] as an alternative may be type approved by The Society.

For a particular type of gearing, a Tasneef Type Approval Certificate valid for 3 years can be obtained by the Manufacturer by testing a prototype according to the requirements contained in [5].

The validity of the certificate in the course of the 3 years is subject to satisfactory results of shop trials witnessed by a Tasneef Surveyor; the periodicity and procedures are to be agreed with The Society on a case-by-case basis.

During the period of the Certificate's validity, and for the next gearing of the same type, the tests required by the Rules can be carried out by the Manufacturer, who will issue a Certificate of conformity to the prototype

5.3.2 Renewal of Tasneef Type Approval Certificate

For the renewal of the Tasneef Type Approval Certificate, the tests to be carried out will be specified in a scheme to be agreed with The Society.

SECTION 7 MAIN PROPULSION SHAFTING

1 General

1.1 Application

1.1.1 This Section applies to shafts, couplings, clutches and other shafting components transmitting power for main propulsion.

For shafting components in engines, turbines, gears and thrusters, see Sec 2, Sec 4, Sec 5, Sec 6 and Sec 12, respectively; for propellers, see Sec 8.

For vibrations, see Sec 9.

Additional requirements for navigation in ice are given in Part F, Chapter 9.

[4] is applicable when requested in accordance with the relevant Table of Pt A, Ch 2, App 3.

1.2 Documentation to be submitted

1.2.1 The Manufacturer is to submit to the Society the documents listed in Tab 1 for approval.

Plans of power transmitting parts and shaft liners listed in Tab 1 are to include the relevant material specifications.

2 Design and construction

2.1 Materials

2.1.1 General

The use of other materials or steels having values of tensile strength exceeding the limits given in [2.1.2], [2.1.3] and [2.1.4] will be considered by the Society in each case.

2.1.2 Shaft materials

In general, shafts are to be of forged steel having tensile strength, R_m, between 400 and 930 N/mm^2.

Where shafts may experience vibratory stresses close (i.e. higher than 80%) to the permissible stresses for transient operation, the materials are to have a specified minimum ultimate tensile strength (R_m) of 500 N/mm^2. Otherwise, materials having a specified minimum ultimate tensile strength (R_m) of 400 N/mm^2 may be used.

Table 1 : Documentation to be submitted

No.	Document (drawings, calculations, etc.)
1	Shafting arrangement **(1)**
2	Thrust shaft
3	Intermediate shafts
4	Propeller shaft
5	Shaft liners, relevant manufacture and welding procedures, if any
6	Couplings and coupling bolts
7	Flexible couplings **(2)**
8	Sterntube
9	Details of sterntube glands
10	Oil piping diagram for oil lubricated propeller shaft bearings

No.	Document (drawings, calculations, etc.)
11	Shaft alignment calculation, see also [3.3]

(1) This drawing is to show the entire shafting, from the main engine coupling flange to the propeller. The location of the thrust block, and the location and number of shafting bearings (type of material and length) are also to be shown.

(2) The Manufacturer of the elastic coupling is also to submit the following data:
- allowable mean transmitted torque (static) for continuous operation
- maximum allowable shock torque
- maximum allowable speed of rotation
- maximum allowable values for radial, axial and angular misalignment

In addition, when the torsional vibration calculation of main propulsion system is required (see Sec 9), the following data are also to be submitted:
- allowable alternating torque amplitude and power loss for continuous operation, as a function of frequency and/or mean transmitted torque
- static and dynamic stiffness, as a function of frequency and/or mean transmitted torque
- moments of inertia of the primary and secondary halves of the coupling
- damping coefficient or damping capability
- properties of rubber components
- for steel springs of couplings: chemical composition and mechanical properties of steel employed.

2.1.3 Couplings, flexible couplings, hydraulic couplings

Non-solid-forged couplings and stiff parts of elastic couplings subjected to torque are to be of forged or cast steel, or nodular cast iron.

Rotating parts of hydraulic couplings may be of grey cast iron, provided that the peripheral speed does not exceed 40m/s.

2.1.4 Coupling bolts

Coupling bolts are to be of forged, rolled or drawn steel.

2.1.5 Shaft liners

Liners are to be of metallic corrosion resistant material complying with the applicable requirements of Part D and with the approved specification, if any; in the case of liners fabricated in welded lengths, the material is to be recognised as suitable for welding.

In general, they are to be manufactured from castings.

For small shafts, the use of liners manufactured from pipes instead of castings may be considered.

Where shafts are protected against contact with seawater not by metal liners but by other protective coatings, the coating procedure is to be approved by the Society.

2.1.6 Sterntubes

Sterntubes are to comply with the requirements of Part B.

2.2 Shafts - Scantling

2.2.1 General

For the check of the scantling, the methods given in [2.2.2] and [2.2.3] apply for intermediate shafts and propeller shafts, respectively. As an alternative, the direct stress calculation method as per [2.2.4] may be applied.

Transitions of diameters are to be designed with either a smooth taper or a blending radius. For guidance, a blending radius equal to the change in diameter is recommended.

2.2.2 Intermediate and thrust shafts

The minimum diameter of intermediate and thrust shafts is not to be less than the value d, in mm, given by the following formula:

$$d = F \cdot k \cdot \left[\frac{P}{n \cdot (1 - Q^4)} \cdot \frac{560}{R_m + 160}\right]^{1/}$$

where:

Q :
- in the case of solid shafts: Q = 0
- in the case of hollow shafts: Q = ratio of the hole diameter to the outer shaft diameter in the section concerned.

where $Q \leq 0,4$, $Q = 0$ is to be taken.

Hollow shafts whose longitudinal axis does not coincide with the longitudinal hole axis will be specially considered by the Society in each case.

F : • 95 for main propulsion systems powered by diesel engines fitted with slip type coupling, by turbines or by electric motors;

• 100 for main propulsion systems powered by diesel engines fitted with other type of couplings.

k : Factor whose value is given in Tab 2 depending upon the different design features of the shafts.

For shaft design features other than those given in the Table, the value of k will be specially considered by the Society in each case.

n : Speed of rotation of the shaft, in r.p.m., corresponding to power P

P : Maximum continuous power of the propulsion machinery for which the classification is requested, in kW.

R_m : Value of the minimum tensile strength of the shaft material, in N/mm^2.

The scantlings of intermediate shafts inside tubes or sterntubes will be subject to special consideration by the Society. Where intermediate shafts inside sterntubes are water lubricated, the requirements of [2.4.7] are to be applied.

2.2.3 Propeller shafts

For propeller shafts in general a minimum specified tensile strength R_m to be introduced in the following formula not exceeding 600 N/mm^2 is to be taken for carbon, carbon manganese and alloy steel.

Where materials with greater specified or actual tensile strengths than the limitations given above are used, reduced shaft dimensions are not acceptable when derived from the formula in this item [2.2.3].

The minimum diameter of the propeller shaft is not to be less than the value d_P, in mm, given by the following formula:

$$d_P = 100 \cdot k_P \cdot \left[\frac{P}{n \cdot (1 - Q^4)} \cdot \frac{560}{R_m + 160}\right]^{1/3}$$

where:

k_p : Factor whose value, depending on the different constructional features of shafts, is given below.

The other symbols have the same meaning as in [2.2.2].

In cases of stainless steels and in other particular cases, at the discretion of the Society, the value of R_m to be introduced in the above formula will be specially considered. In general, the diameter of the part of the propeller shaft located forward of the forward sterntube seal may be gradually reduced to the diameter of the intermediate shaft.

The values of factor k_P to be introduced in the above formula are to be taken as follows:

k_P : $k_P = 1,26$, for propeller shafts where:

- the propeller is keyed on to the shaft taper in compliance with the requirements of [2.5.5]

$k_P = 1,22$, for propeller shafts where:

- the propeller is keyless fitted on to the shaft taper by a shrinkage method in compliance with Sec 8, [3.1.2], or the propeller boss is attached to an integral propeller shaft flange in compliance with [2.5.1]
- the sterntube of the propeller shaft is oil lubricated and provided with oil sealing glands approved by the Society or when the sterntube is water lubricated and the propeller shaft is fitted with a continuous liner.

The above values of k_P apply to the portion of propeller shaft between the forward edge of the aftermost shaft bearing and the forward face of the propeller boss or the forward face of the integral propeller shaft flange for the connection to the propeller boss. In no case is the length of this portion of propeller shaft to be less than 2,5 times the rule diameter d_P obtained with the above formula.

The determination of factor k_P for shaft design features other than those given above will be specially considered by the Society in each case.

For the length of the propeller shaft between the forward edge of the aftermost shaft bearing and the forward edge of the forward sterntube seal:

- $k_P = 1,15$ is to be taken in any event.

2.2.4 Direct stress calculation method

Alternative calculation methods may be considered by the Society. Any alternative calculation method is to include all relevant loads on the complete dynamic shafting system under all permissible operating conditions. Consideration is to be given to the dimensions and arrangements of all shaft connections.

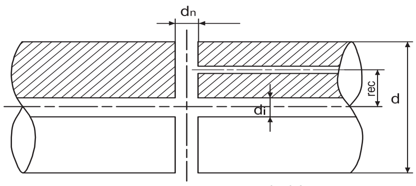
Moreover, an alternative calculation method is to take into account design criteria for continuous and transient operating loads (dimensioning for fatigue strength) and for peak operating loads (dimensioning for yield strength). The fatigue strength analysis may be carried out separately according to different criteria corresponding to different load assumptions, for example the following:

- low cycle fatigue criterion (typically lower than 10^4), i.e. the primary cycles represented by zero to full load and back to zero, including reversing torque if applicable
- high cycle fatigue criterion (typically much higher than 10^7), i.e. torsional vibration stresses permitted for continuous operation, reverse bending stresses and operation passing through a barred speed range or any other transient condition.

Table 2 : Values of factor k

For intermediate shafts with					For thrust shafts external to engines	
integral coupling flange and straight sections	shrink fit coupling	keyways, tapered or cylindrical connection	radial hole	longitudinal slot	on both sides of thrust collar	in way of axial bearing, where a roller bearing is used as a thrust bearing
1,00 **(1)**	1,00 **(2)**	1,10 **(3)** **(4)**	1,10 **(5)**	1,20 **(6)**	1,10 **(1)**	1,10

(1) Value applicable in the case of fillet radii in accordance with the provisions of [2.5.1].
(2) k refers to the plain shaft section only. Where shafts may experience vibratory stresses close to the permissible stresses for continuous operation, an increase in diameter to the shrink fit diameter is to be provided, e.g. a diameter increase of 1 to 2 % and a blending radius as described in [2.2.1].
(3) Keyways are, in general, not to be used in installations with a barred speed range.
(4) At a distance of not less than 0,2 d from the end of the keyway, the shaft diameter may be reduced to the diameter calculated using k = 1,0. Fillet radii in the transverse section of the bottom of the keyway are to be not less than 0,0125 d, d being the diameter as calculated above using k = 1,0.
(5) Value applicable in the case of diameter of radial bore d_h not exceeding 0,3 d, d being as defined in **(4)**.
Cases foreseeing intersection between a radial and an eccentric (r_{ec}) axial bore (see figure below) are specially considered by the Society.



(6) Subject to limitations: slot length (l)/outside diameter < 0,8, inner diameter (d_i)/outside diameter < 0,7 and slot width (e)/outside diameter > 0,15. The end rounding of the slot is not to be less than e/2. An edge rounding is preferably to be avoided as this increases the stress concentration slightly.The k values are valid for 1, 2 and 3 slots, i.e. with slots at, respectively, 360, 180 and 120 degrees apart.

Note 1: Explanation of k and C_K (for C_K see Sec 9, Tab 1)
The factors k (for low cycle fatigue) and C_K (for high cycle fatigue) take into account the influence of:

- the stress concentration factors (scf) relative to the stress concentration for a flange with fillet radius of 0,08 d (geometric stress concentration of approximately 1,45)

$$C_K = \frac{1,45}{scf} \quad \text{and} \quad k = \left(\frac{scf}{1,45}\right)^x$$

where the exponent x considers low cycle notch sensitivity.
- the notch sensitivity. The chosen values are mainly representative for soft steels (R_m < 600), while the influence of steep stress gradients in combination with high strength steels may be underestimated.
- the fact that that the size factor c_D being a function of diameter only does not purely represent a statistical size influence, but rather a combination of this statistical influence and the notch sensitivity.

The actual values for k and C_K are rounded off.

Note 2: Stress concentration factor of slots
The stress concentration factor (scf) at the end of slots can be determined by means of the following empirical formulae using the symbols in **(4)**

$$scf = \alpha_{t(hole)} + 0,8 \cdot \frac{(l-e)/d}{\sqrt{\left(1-\frac{d_i}{d}\right) \cdot \frac{e}{d}}}$$

This formula applies to:
- slots at 120 or 180 or 360 degrees apart.
- slots with semicircular ends. A multi-radii slot end can reduce the local stresses, but this is not included in this empirical formula.
- slots with no edge rounding (except chamfering), as any edge rounding increases the scf slightly.

$a_{t(hole)}$ represents the stress concentration of radial holes (in this context e = hole diameter) and can be determined as :

$$\alpha_{t(hole)} = 2,3 - 3 \cdot \frac{e}{d} + 15 \cdot \left(\frac{e}{d}\right)^2 + 10 \cdot \left(\frac{e}{d}\right)^2 \cdot \left(\frac{d_i}{d}\right)^2$$

or simplified to $a_{t(hole)}$ = 2,3.

Note 3: The determination of k factors for shafts other than those provided in this table will be given special consideration by the Society.

2.3 Liners

2.3.1 General

Metal liners or other protective coatings approved by the Society are required where propeller shafts are not made of corrosion-resistant material.

Metal liners are generally to be continuous; however, discontinuous liners, i.e. liners consisting of two or more separate lengths, may be accepted by the Society on a case by case basis, provided that:

- they are fitted in way of all supports
- the shaft portion between liners, likely to come into contact with sea water, is protected with a coating of suitable material with characteristics, fitting method and thickness approved by the Society.

2.3.2 Scantling

The thickness of metal liners fitted on propeller shafts or on intermediate shafts inside sterntubes is to be not less than the value t, in mm, given by the following formula:

$$t = \frac{d + 230}{32}$$

where:

d : Actual diameter of the shaft, in mm.

Between the sternbushes, the above thickness t may be reduced by 25%.

2.4 Stern tube bearings

2.4.1 Oil lubricated aft bearings of antifriction metal

a) The length of bearings lined with white metal or other antifriction metal and with oil glands of a type approved by the Society is to be not less than twice the rule diameter of the shaft in way of the bearing.

b) The length of the bearing may be less than that given in (a) above, provided the nominal bearing pressure is not more than 0,8 N/mm^2, as determined by static bearing reaction calculations taking into account shaft and propeller weight, as exerting solely on the aft bearing, divided by the projected area of the shaft.

However, the minimum bearing length is to be not less than 1,5 times its actual inner diameter.

2.4.2 Oil lubricated aft bearings of synthetic rubber, reinforced resin or plastic materials

a) For bearings of synthetic rubber, reinforced resin or plastics material which are approved by the Society for use as oil lubricated sternbush bearings, the length of the bearing is to be not less than twice the rule diameter of the shaft in way of the bearing.

b) The length of the bearing may be less than that given in (a) above provided the nominal bearing pressure is not more than 0,6 N/mm^2, as determined according to [2.4.1] b).

However, the minimum length of the bearing is to be not less than 1,5 times its actual inner diameter.

Where the material has proven satisfactory testing and operating experience, consideration may be given to an increased bearing pressure.

c) Synthetic materials for application as oil lubricated stern tube bearings are to be Type Approved.

2.4.3 Water lubricated aft bearings of lignum vitae or antifriction metal

Where the bearing comprises staves of wood (known as "lignum vitae") or is lined with antifriction metal, the length of the bearing is to be not less than 4 times the rule diameter of the shaft in way of the bearing.

2.4.4 Water lubricated aft bearings of synthetic materials

a) The length of the bearing is to be not less than 4 times the rule diameter of the shaft in way of the bearing.

b) For a bearing of synthetic material, consideration may be given to a bearing length less than 4 times, but in no case less than 2 times, the rule diameter of the shaft in way of the bearing, provided the bearing design and material is substantiated by experiments to the satisfaction of the Society.

c) Synthetic materials for application as water lubricated stern tube bearings are to be Type Approved.

2.4.5 Grease lubricated aft bearings

The length of grease lubricated bearings is to be not less than 4 times the rule diameter of the shaft in way of the bearing.

2.4.6 Oil or grease lubrication system

a) For oil lubricated bearings, provision for oil cooling is to be made.

A gravity tank is to be fitted to supply lubricating oil to the sterntube; the tank is to be located above the full load waterline.

Oil sealing glands are to be suitable for the various sea water temperatures which may be encountered in service.

b) Grease lubricated bearings will be specially considered by the Society.

2.4.7 Water circulation system

For water lubricated bearings, means are to be provided to ensure efficient water circulation. In the case of bearings lined with "lignum vitae" of more than 400 mm in diameter and bearings lined with synthetic materials, means for forced water circulation are to be provided. In the case of bearings of synthetic materials, water flow indicators or pump outlet pressure indicators are to be provided.

The water grooves on the bearings are to be of ample section such as to ensure efficient water circulation and be scarcely affected by wear-down, particularly for bearings of the plastic type.

The shut-off valve or cock controlling the water supply is to be fitted direct to the stuffing box bulkhead or in way of the water inlet to the sterntube, when this is fitted forward of such bulkhead.

2.5 Couplings

2.5.1 Flange couplings

a) Flange couplings of intermediate and thrust shafts and the flange of the forward coupling of the propeller shaft are to have a thickness not less than 0,2 times the rule diameter of the solid intermediate shaft and not less than the coupling bolt diameter calculated for a tensile strength equal to that of the corresponding shaft.

Special consideration will be given by the Society to flanges having non-parallel faces, but in no case is the thickness of the flange to be less than the coupling bolt diameter.

The fillet radius at the base of solid forged flanges is to be not less than 0,08 times the actual shaft diameter.

The fillet may be formed of multi-radii in such a way that the stress concentration factor will not be greater than that for a circular fillet with radius 0,08 times the actual shaft diameter.

For non-solid forged flange couplings, the above fillet radius is not to cause a stress in the fillet higher than that caused in the solid forged flange as above.

Fillets are to have a smooth finish and are not to be recessed in way of nuts and bolt heads.

b) Where the propeller is connected to an integral propeller shaft flange, the thickness of the flange is to be not less than 0,25 times the rule diameter of the aft part of the propeller shaft. The fillet radius at the base of the flange is to be not less than 0,125 times the actual diameter.

The strength of coupling bolts of the propeller boss to the flange is to be equivalent to that of the aft part of the propeller shaft.

c) Non-solid forged flange couplings and associated keys are to be of a strength equivalent to that of the shaft.

They are to be carefully fitted and shrunk on to the shafts, and the connection is to be such as to reliably resist the vibratory torque and astern pull.

d) For couplings of intermediate and thrust shafts and for the forward coupling of the propeller shaft having all fitted coupling bolts, the coupling bolt diameter in way of the joining faces of flanges is not to be less than the value d_B, in mm, given by the following formula:

$$d_B = 0,65 \cdot \left[\frac{d^3 \cdot (R_m + 160)}{n_B \cdot D_C \cdot R_{mB}}\right]^{0,5}$$

where:

- d : Rule diameter of solid intermediate shaft, in mm, taking into account the ice strengthening requirements of Pt F, Ch 9, Sec 3, where applicable
- n_B : Number of fitted coupling bolts
- D_C : Pitch circle diameter of coupling bolts, in mm
- R_m : Value of the minimum tensile strength of intermediate shaft material taken for calculation of d, in N/mm^2
- R_{mB} : Tensile strength of the fitted coupling bolts material taken for calculation, in N/mm^2. The value of the tensile strength of the bolt material taken for calculation R_{mB} is to comply with the following requirements:
  - $R_m <= R_{mB} <= 1,7\ R_m$
  - $R_{mB} <= 1000$ N/mm^2

e) Flange couplings with non-fitted coupling bolts may be accepted on the basis of the calculation of bolt tightening, bolt stress due to tightening, and assembly instructions.

To this end, the torque based on friction between the mating surfaces of flanges is not to be less than 2,8 times the transmitted torque, assuming a friction coefficient for steel on steel of 0,18. In addition, the bolt stress due to tightening in way of the minimum cross-section is not to exceed 0,8 times the minimum yield strength (R_{eH}), or 0,2 proof stress ($R_{p\,0,2}$), of the bolt material.

Transmitted torque has the following meanings:

- For main propulsion systems powered by diesel engines fitted with slip type or high elasticity couplings, by turbines or by electric motors: the mean transmitted torque corresponding to the maximum continuous power P and the relevant speed of rotation n, as defined under [2.2.2].
- For main propulsion systems powered by diesel engines fitted with couplings other than those above-mentioned: the mean torque above increased by 20% or by the torque due to torsional vibrations, whichever is the greater.

The value 2,8 above may be reduced to 2,5 in the following cases:

- s having two or more main propulsion shafts
- when the transmitted torque is obtained, for the whole functioning rotational speed range, as the sum of the nominal torque and the alternate torque due to the torsional vibrations, calculated as required in Sec 9.

2.5.2 Shrunk couplings

Non-integral couplings which are shrunk on the shaft by means of the oil pressure injection method or by other means may be accepted on the basis of the calculation of shrinking and induced stresses, and assembly instructions.

To this end, the force due to friction between the mating surfaces is not to be less than 2,8 times the total force due to the transmitted torque and thrust.

The value 2,8 above may be reduced to 2,5 in the cases specified under item e) of [2.5.1].

The values of 0,14 and 0,18 will be taken for the friction coefficient in the case of shrinking under oil pressure and dry shrink fitting, respectively.

In addition, the equivalent stress due to shrinkage determined by means of the von Mises-Hencky criterion in the points of maximum stress of the coupling is not to exceed 0,8 times the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p0,2}$), of the material of the part concerned.

The transmitted torque is that defined under item e) of [2.5.1].

For the determination of the thrust, see Sec 8, [3.1.2].

2.5.3 Other couplings

Types of couplings other than those mentioned in [2.5.1] and [2.5.2] above will be specially considered by the Society.

2.5.4 Flexible couplings

a) The scantlings of stiff parts of flexible couplings subjected to torque are to be in compliance with the requirements of Article [2].

b) For flexible components, the limits specified by the Manufacturer relevant to static and dynamic torque, speed of rotation and dissipated power are not to be exceeded.

c) Where all the engine power is transmitted through one flexible component only (s with one propulsion engine and one shafting only), the flexible coupling is to be fitted with a torsional limit device or other suitable means to lock the coupling should the flexible component break.

In stiff transmission conditions with the above locking device, a sufficiently wide speed range is to be provided, free from excessive torsional vibrations, such as to enable safe navigation and steering of the . As an alternative, a spare flexible element is to be provided on board.

2.5.5 Propeller shaft keys and keyways

a) Keyways on the propeller shaft cone are to have well rounded corners, with the forward end faired and preferably spooned, so as to minimize notch effects and stress concentrations.

When these constructional features are intended to obtain an extension of the interval between surveys of the propeller shaft in accordance with the relevant provisions of Pt A, Ch 2, Sec 2, [8.1], they are to be in compliance with Fig 1.

Different scantlings may be accepted, provided that at least the same reduction in stress concentration is ensured.

The fillet radius at the bottom of the keyway is to be not less than 1,25% of the actual propeller shaft diameter at the large end of the cone.

The edges of the key are to be rounded.

The distance from the large end of the propeller shaft cone to the forward end of the key is to be not less than 20% of the actual propeller shaft diameter in way of the large end of the cone.

Key securing screws are not to be located within the first one-third of the cone length from its large end; the edges of the holes are to be carefully faired.

b) The sectional area of the key subject to shear stress is to be not less than the value A, in mm², given by the following formula:

$$A = 0,4 \cdot \frac{d^3}{d_{PM}}$$

where:

d : Rule diameter, in mm, of the intermediate shaft calculated in compliance with the requirements of [2.2.2], assuming:

$R_m = 400$ N/mm²

d_{PM} : Actual diameter of propeller shaft at mid-length of the key, in mm.

2.6 Control and monitoring

2.6.1 General

In addition to those given in this item [2.6], the requirements of Chapter 3 apply.

In the case of s with automation notations, the requirements in Part F, Chapter 3 also apply.

2.6.2 Propeller shaft monitoring

For the assignment of the propeller shaft monitoring system notation, see Pt F, Ch 5, Sec 2.

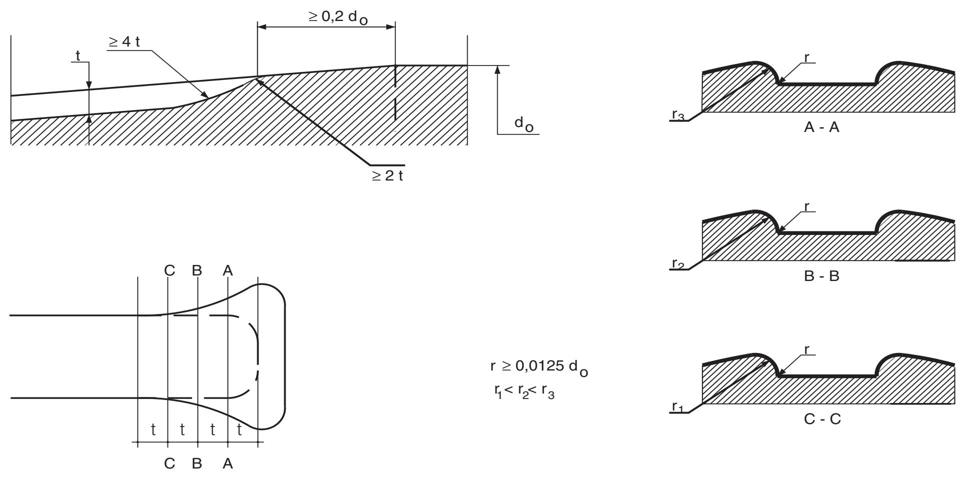
2.6.3 Indicators

The local indicators for main propulsion shafting to be installed on yachts without automation notations are given in Tab 3. For monitoring of engines, turbines, gears, controllable pitch propellers and thrusters, see Sec 2, Sec 4, Sec 6, Sec 8 and Sec 12, respectively.

The indicators listed in Tab 3 are to be fitted at a normally attended position.

Note 1: Some departures from Tab 3 may be accepted by the Society in the case of s with a restricted navigation notation

Figure 1 : Details of forward end of propeller shaft keyway



3 Arrangement and installation

3.1 General

3.1.1 The installation is to be carried out according to the instructions of the component Manufacturer or approved documents, when required.

3.1.2 The installation of sterntubes and/or associated non-shrunk bearings is subject to approval of procedures and materials used.

3.1.3 The joints between liner parts are not to be located in way of supports and sealing glands.

Metal liners are to be shrunk on to the shafts by pre-heating or forced on by hydraulic pressure with adequate interference; dowels, screws or other means of securing the liners to the shafts are not acceptable.

3.2 Protection of propeller shaft against corrosion

3.2.1 The propeller shaft surface between the propeller and the sterntube, and in way of propeller nut, is to be suitably protected in order to prevent any entry of sea water, unless the shaft is made of austenitic stainless steel.

3.3 Shaft alignment

3.3.1 The Society may require the above calculation in the case of special arrangements.

The alignment of the propulsion machinery and shafting and the spacing and location of the bearings are to be such as to ensure that the loads are compatible with the material used and the limits prescribed by the Manufacturer.

The calculation is to take into account thermal, static and dynamic effects; the results are to include the reaction forces of bearings, bending moments, shear stresses and other parameters (such as gap and sag of each flanged coupling or jacking loads) and instructions for the alignment procedure.

The alignment is to be checked on board by a suitable measurement method.

Reference may be done to Pt C, Ch 1, Sec 7, [3.3] of the Tasneef Rules for the Classification of Ships

4 Material tests, workshop inspection and testing, certification

4.1 Material and non-destructive tests, workshop inspections and testing

4.1.1 Material tests

Shafting components are to be tested in accordance with Tab 4 and in compliance with the requirements of Part D.

Magnetic particle or liquid penetrant tests are required for the parts listed in Tab 4 and are to be effected in positions mutually agreed upon by the Manufacturer and the Surveyor, where experience shows defects are most likely to occur.

Table 3 : Shafting of propulsion machinery

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Main Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Temperature of each shaft thrust bearing (non applicable for ball or roller bearings)	H		X				
Stern tube bush oil gravity tank level	L						

4.1.2 Hydrostatic tests

Parts of hydraulic couplings, clutches of hydraulic reverse gears and control units, hubs and hydraulic cylinders of controllable pitch propellers, including piping systems and associated fittings, are to be hydrostatically tested to1,5 times the maximum working pressure.

Sterntubes, when machine-finished, and propeller shaft liners, when machine-finished on the inside and with an overthickness not exceeding 3 mm on the outside, are to be hydrostatically tested to 0,2 MPa.

4.2 Certification

4.2.1 Testing certification

Society's certificates (C) (see Pt D, Ch 1, Sec 1, [4.2.1]) are required for material tests of components in items 1 to 5 of Tab 4 when required in Pt A Ch.2 App.3.

Works' certificates (W) (see Pt D, Ch 1, Sec 1, [4.2.3]) are required for hydrostatic tests of components indicated in [4.1.2] and for material and non-destructive tests of components in items of Tab 4 other than those for which Society's certificates (C) are required.

Table 4 : Material and non-destructive tests

Shafting component	Material tests (Mechanical properties and chemical composition)	Non-destructive tests	
		Magnetic particle or liquid penetrant	Ultrasonic
1) Coupling (separate from shafts)	all	if diameter ≥ 250 mm	if diameter ≥ 250 mm
2) Propeller shafts	all	if diameter ≥ 250 mm	if diameter ≥ 250 mm
3) Intermediate shafts	all	if diameter ≥ 250 mm	if diameter ≥ 250 mm
4) Thrust shafts	all	if diameter ≥ 250 mm	if diameter ≥ 250 mm
5) Cardan shafts (flanges, crosses, shafts, yokes)	all	if diameter ≥ 250 mm	if diameter ≥ 250 mm
6) Sterntubes	all	-	-
7) Sterntube bushes and other shaft bearings	all	-	-
8) Propeller shaft liners	all	-	-
9) Coupling bolts or studs	all	-	-
10) Flexible couplings (metallic parts only)	all	-	-
11) Thrust sliding-blocks (frame only)	all	-	-

SECTION 8 PROPELLERS

1 General

1.1 Application

1.1.1 Propulsion propellers

The requirements of this Section apply to propellers of any size and type intended for propulsion. They include fixed and controllable pitch propellers, including those ducted in fixed nozzles.

Additional requirements for navigation in ice are given in Pt F, Ch 9, Sec 3.

[4] is applicable when requested in accordance with the relevant Table of Pt A, Ch 2, App 3.

1.1.2 Manoeuvring thruster propellers

For manoeuvring thruster propellers see Sec 12.

1.2 Definitions

1.2.1 Solid propeller

A solid propeller is a propeller (including hub and blades) cast in one piece.

1.2.2 Built-up propeller

A built-up propeller is a propeller cast in more than one piece. In general, built up propellers have the blades cast separately and fixed to the hub by a system of bolts and studs.

1.2.3 Controllable pitch propellers

Controllable pitch propellers are built-up propellers which include in the hub a mechanism to rotate the blades in order to have the possibility of controlling the propeller pitch in different service conditions.

1.2.4 Nozzle

A nozzle is a circular structural casing enclosing the propeller.

1.2.5 Ducted propeller

A ducted propeller is a propeller installed in a nozzle.

1.2.6 Skewed propellers

Skewed propellers are propellers whose blades have a skew angle other than 0.

1.2.7 Highly skewed propellers and very highly skewed propellers

Highly skewed propellers are propellers having blades with skew angle between 25^o and 50^o. Very highly skewed propellers are propellers having blades with skew angle exceeding 50^o.

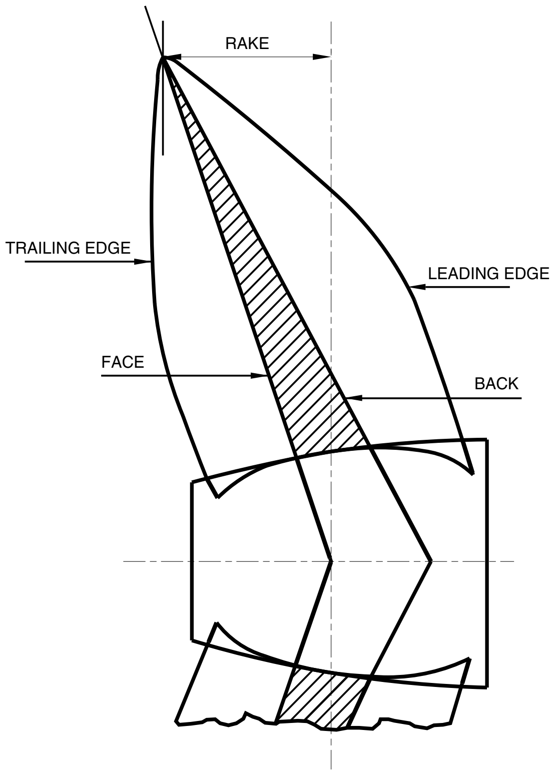
1.2.8 Leading edge

The leading edge of a propeller blade is the edge of the blade at side entering the water while the propeller rotates (see Fig 1).

1.2.9 Trailing edge

The trailing edge of a propeller blade is the edge of the blade opposite the leading edge (see Fig 1).

Figure 1 : Rake



1.2.10 Developed area ratio

Developed area ratio is the ratio of the total blade developed area to the area of the ring included between the propeller diameter and the hub diameter.

1.3 Documentation to be submitted

1.3.1 Solid propellers

The documents listed in Tab 1 are to be submitted for solid propellers intended for propulsion.

All listed plans are to be constructional plans complete with all dimensions and are to contain full indication of types of materials employed.

Table 1 : Documents to be submitted for solid propellers

No.	A/I **(1)**	ITEM
1	A	Sectional assembly
2	A	Blade and hub details
3	I	Rating (power, rpm, etc.)
4	A	Data and procedures for fitting propeller to the shaft
(1) A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

1.3.2 Built-up and controllable pitch propellers

The documents listed in Tab 2, as applicable, are to be submitted for built-up and controllable pitch propellers intended for propulsion.

Table 2 : Documents to be submitted for built-up and controllable pitch propellers

No.	A/I **(1)**	ITEM
1	A/I	Same documents requested for solid propellers
2	A	Blade bolts and pre-tensioning procedures
3	I	Pitch corresponding to maximum propeller thrust and to normal service condition

No.	A/I **(1)**	ITEM
4	A	Pitch control mechanism
5	A	Pitch control hydraulic system
(1) A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

1.3.3 Very highly skewed propellers and propellers of unusual design

For very highly skewed propellers and propellers of unusual design, in addition to the documents listed in Tab 1 and Tab 2, as applicable, a detailed hydrodynamic load and stress analysis is to be submitted (see [2.4.2]).

2 Design and construction

2.1 Materials

2.1.1 Normally used materials for propeller hubs and blades

a) Tab 3 indicates the minimum tensile strength R_m (in N/mm^2), the density δ (in kg/dm^3) and the material factor f of normally used materials.

b) Common bronze, special types of bronze and cast steel used for the construction of propeller hubs and blades are to have a minimum tensile strength of 400 N/mm^2.

c) Other materials are subject of special consideration by the Society following submission of full material specification.

Table 3 : Normally used materials for propeller blades and hub

Material	R_m	δ	f
Common brass	400	8,3	7,6
Manganese brass (Cu1)	440	8,3	7,6
Nickel-manganese brass (Cu2)	440	8,3	7,9
Aluminium bronze (Cu3 and Cu4)	590	7,6	8,3
Steel	440	7,9	9,0

2.1.2 Materials for studs

In general, steel (preferably nickel-steel) is to be used for manufacturing the studs connecting steel blades to the hub of built-up or controllable pitch propellers, and high tensile brass or stainless steel is to be used for studs connecting bronze blades.

2.2 Solid propellers - Blade thickness

2.2.1

a) The maximum thickness $t_{0.25}$, in mm, of the solid propeller blade at the section at 0,25 radius from the propeller axis is not to be less than that obtained from the following formula:

$$t_{0,25} = 3,2\left[f\cdot\frac{1,5.10^6.\rho.M_T + 51.\delta.\left(\frac{D}{100}\right)^3.B.I.N^2.h}{I\cdot z\cdot R_m}\right]^{0,5}$$

where:

f : Material factor as indicated in Tab 3

ρ : D/H

H : Mean pitch of propeller, in m. When H is not known, the pitch $H_{0.7}$ at 0,7 radius from the propeller axis, may be used instead of H.

D : Propeller diameter, in m

M_T : Continuous transmitted torque, in kN.m; where not indicated, the value given by the following formula may be assumed for M_T :

$$M_T = 9{,}55 \cdot \left(\frac{P}{N}\right)$$

P : Maximum continuous power of propulsion machinery, in kW

N : Rotational speed of the propeller, in rev/min

δ : Density of blade material, in kg/dm^3, as indicated in Tab 3

B : Expanded area ratio

h : Rake, in mm

l : Developed width of blade section at 0,25 radius from propeller axis, in mm

z : Number of blades

R_m : Minimum tensile strength of blade material, in N/mm^2.

b) The maximum thickness $t_{0.6}$, in mm, of the solid propeller blade at the section at 0,6 radius from the propeller axis is not to be less than that obtained from the following formula:

$$t_{0,6} = 1{,}9\left[f\,\frac{1{,}5.10^6.\rho_{0,6}.M_T + 18{,}4.\delta.\left(\frac{D}{100}\right)^3.B.l.N^2.h}{l_{0,6}\cdot z\cdot R_m}\right]^{0,5}$$

where:

$\rho_{0,6}$: $D/H_{0.6}$

$H_{0.6}$: Pitch at 0,6 radius from the propeller axis, in m

$l_{0.6}$: Developed width of blade section at 0,6 radius from propeller axis, in mm.

c) The radius at the blade root is to be at least ¾ of the required minimum thickness $t_{0,25}$. As an alternative, constant stress fillets may also be considered. When measuring the thickness of the blade, the increased thickness due to the radius of the fillet at the root of the blade is not to be taken into account. If the propeller hub extends over 0,25 radius, the thickness calculated by the formula in a) is to be compared with the thickness obtained by linear interpolation of the actual blade thickness up to 0,25 radius.

d) As an alternative to the above formulae, a detailed hydrodynamic load and stress analysis carried out by the propeller designer may be considered by the Society, on a case by case basis. The safety factor to be used in this analysis is not to be less than 8 with respect to the ultimate tensile strength of the propeller material R_m.

2.3 Built-up propellers and controllable pitch propellers

2.3.1 Blade thickness

a) The maximum thickness $t_{0,35}$, in mm, of the blade at the section at 0,35 radius from the propeller axis is not to be less than that obtained from the following formula:

$$t_{0,35} = 2{,}7\left[f\,\frac{1{,}5.10^6.\rho_{0,7}.M_T + 41.\delta\left(\frac{D}{100}\right)^3 B.l_{0,35}.N^2 h}{l_{0,35}\cdot z\cdot R_m}\right]^{0,5}$$

where:

$\rho_{0,7}$: $D/H_{0.7}$

$H_{0.7}$: Pitch at 0,7 radius from the propeller axis, in m. The pitch to be used in the formula is the actual pitch of the propeller when the propeller develops the maximum thrust.

$l_{0.35}$: Developed width of blade section at 0,35 radius from propeller axis, in mm.

b) The maximum thickness $t_{0.6}$, in mm, of the propeller blade at the section at 0,6 radius from the propeller axis is not to be less than that obtained from the formula in [2.2.1], item b, using the value of $l_{0,35}$ in lieu of l.

c) The radius at the blade root is to be at least ¾ of the required minimum thickness $t_{0,35}$. As an alternative, constant stress fillets may also be considered. When measuring the thickness of the blade, the increased thickness due to the radius of the fillet at the root of the blade is not to be taken into account.

d) As an alternative to the above formulae, a detailed hydrodynamic load and stress analysis carried out by the propeller designer may be considered by the Society, on a case by case basis. The safety factor to be used in this analysis is not to be less than 8 with respect to the ultimate tensile strength of the propeller blade material R_m.

2.3.2 Flanges for connection of blades to hubs

a) The diameter D_F, in mm, of the flange for connection to the propeller hub is not to be less than that obtained from the following formula:

$$D_F = D_C + 1{,}8 d_{PR}$$

where:

D_C : Stud pitch circle diameter, in mm

d_{PR} : Diameter of studs.

b) The thickness of the flange is not to be less than 1/10 of the diameter D_F.

2.3.3 Connecting studs *(1/7/2002)*

a) The diameter d_{PR}, in mm, at the bottom of the thread of the studs is not to be less than that obtained from the following formula:

$$d_{PR} = \left(\frac{4{,}6.10^7.\rho_{0,7}.M_T + 0{,}88.\delta.\left(\frac{D}{10}\right)^3.B.l_{0,35}.N^2.h_1}{n_{PR} \cdot z \cdot D_C \cdot R_{m,PR}} \right)^{0,5}$$

where:

h_1 : h + 1,125 D_C

n_{PR} : Total number of studs in each blade,

$R_{m,PR}$: Minimum tensile strength of stud material, in N/mm^2.

b) The studs are to be tightened in a controlled manner such that the tension on the studs is approximately 60-70 % of their yield strength.

c) The shank of studs may be designed with a minimum diameter equal to 0,9 times the root diameter of the thread.

d) The studs are to be properly secured against unintentional loosening.

2.4 Skewed propellers

2.4.1 Skewed propellers

The thickness of skewed propeller blades may be obtained by the formulae in [2.2] and [2.3.1], as applicable, provided the skew angle is less than 25^o.

2.4.2 Highly skewed propellers

a) For solid and controllable pitch propellers having skew angles between 25^o and 50^o, the blade thickness, in mm, is not to be less than that obtained from the following formulae:

1) For solid propellers

$$t_{S-0,25} = t_{0,25} \cdot (0{,}92 + 0{,}0032\vartheta)$$

2) For built-up and controllable pitch propellers

$$t_{S-0,35} = t_{0,35} \cdot (0{,}9 + 0{,}004\vartheta)$$

3) For all propellers

$$t_{S-0,6} = t_{0,6} \cdot (0{,}74 + 0{,}0129\vartheta - 0{,}0001\vartheta^2)$$

$$t_{S-0,9} = t_{0,6} \cdot (0{,}35 + 0{,}0015\vartheta)$$

where:

$t_{S-0,25}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,25 radius from the propeller axis

$t_{0,25}$: Maximum thickness, in mm, of normal shape propeller blade at the section at 0,25 radius from the propeller axis, obtained by the formula in [2.2.1]

$t_{S-0,35}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,35 radius from the propeller axis

$t_{0,35}$: Maximum thickness, in mm, of normal shape propeller blade at the section at 0,35 radius from the propeller axis, obtained by the formula in [2.3.1]

$t_{S-0,6}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,6 radius from the propeller axis

$t_{0,6}$: Maximum thickness, in mm, of normal shape propeller blade at the section at 0,6 radius from the propeller axis, obtained by the formula in [2.2.1]

$t_{S-0,9}$: Maximum thickness, in mm, of skewed propeller blade at the section at 0,9 radius from the propeller axis

ϑ : Skew angle.

b) As an alternative, highly skewed propellers may be accepted on the basis of a stress analysis, as stated in [2.4.3] for very highly skewed propellers.

2.4.3 Very highly skewed propellers

For very highly skewed propellers, the blade thickness is to be obtained by a stress analysis according to a calculation criteria accepted by the Society. The safety factor to be used in this direct analysis is not to be less than 9 with respect to the ultimate tensile strength of the propeller blade material, R_m.

2.5 Ducted propellers

2.5.1 The minimum blade thickness of propellers with wide tip blades running in nozzles is not to be less than the values obtained by the applicable formula in [2.2] or [2.3.1], increased by 10%.

2.6 Features

2.6.1 Blades and hubs

a) All parts of propellers are to be free of defects and are to be built and installed with clearances and tolerances in accordance with sound marine practice.

b) Particular care is to be taken with the surface finish of the blades.

2.6.2 Controllable pitch propellers pitch control system

a) The general requirements given in Sec 10, [14] apply.

b) Separate oil systems intended for the control of controllable pitch propellers are to include at least two power pumps, of such a capacity as to maintain normal control with any one pump out of action.

c) In the case of propulsion plants comprising:
   - more than one shaft line with the propellers fitted with their own control system,
   - or one engine with an output not exceeding 375 kW,

   one of the pumps mentioned in b) may be a spare pump ready to be connected to the oil control system, provided disassembling and reassembling operations can be carried out on board in a short time.

d) However, when the propulsion plant comprises one or more engines, each with an output not exceeding 375 kW, the standby or spare pump may be omitted for the controllable pitch propellers provided that they are so designed as to be fixed mechanically in the "forward" position and that the capacity of the starting means ensures the numbers of starts required in such conditions.

e) Pitch control systems are to be provided with an engine room indicator showing the actual setting of the blades. Further blade position indicators are to be mounted on the bridge and in the engine control room, if any.

f) Suitable devices are to be fitted to ensure that an alteration of the blade setting cannot overload the propulsion plant or cause it to stall.

g) Steps are to be taken to ensure that, in the event of failure of the control system, the setting of the blades
   - does not change, or
   - assumes a final position slowly enough to allow the emergency control system to be put into operation.

h) Controllable pitch propeller systems are to be equipped with means of emergency control enabling the controllable pitch propeller to operate should the remote control system fail. This requirement may be complied with by means of a device which locks the propeller blades in the "ahead" setting.

i) Tab 4 indicates the monitoring requirements to be displayed at the control console. In addition, the general requirements given in Chapter 3 apply. In the case of s with automation notations, the requirements in Part F, Chapter 3 also apply.

3 Arrangement and installation

3.1 Fitting of propeller on the propeller shaft

3.1.1 General

a) Screw propeller hubs are to be properly adjusted and fitted on the propeller shaft cone.

b) The forward end of the hole in the hub is to have the edge rounded to a radius of approximately 6 mm.

c) In order to prevent any entry of sea water under the liner and onto the end of the propeller shaft, the arrangement of Fig 2 is generally to be adopted for assembling the liner and propeller boss.

d) The external stuffing gland is to be provided with a seawater resistant rubber ring preferably without joints. The clearance between the liner and the internal air space of the boss is to be as small as possible. The internal air space is to be filled with an appropriate protective material which is insoluble in sea water and non-corrodible or fitted with a rubber ring.

e) All free spaces between the propeller shaft cone, propeller boss, nut and propeller cap are to be filled with a material which is insoluble in sea water and non-corrodible. Arrangements are to be made to allow any air present in these spaces to withdraw at the moment of filling. It is recommended that these spaces be tested under a pressure at least equal to that corresponding to the immersion of the propeller in order to check the tightness obtained after filling.

f) For propeller keys and key area, see Sec 7, [2.5.5].

3.1.2 Shrinkage of keyless propellers

In the case of keyless shrinking of propellers, the following requirements apply:

a) The meaning of the symbols used in the subparagraphs below is as follows:

A : 100% theoretical contact area between propeller boss and shaft, as read from plans and disregarding oil grooves, in mm^2

d_{PM} : Diameter of propeller shaft at the mid-point of the taper in the axial direction, in mm

d_H : Mean outer diameter of propeller hub at the axial position corresponding to d_{PM}, in mm

K : $K = d_H/d_{PM}$

F : Tangential force at interface, in N

M_T : Continuous torque transmitted; in N.m, where not indicated, M_T may be assumed as indicated in [2.2.1]

C :
- C = 1 for turbines, geared diesel engines, electrical drives and direct-drive reciprocating internal combustion engines with a hydraulic, electromagnetic or high elasticity coupling,
- C = 1,2 for diesel engines having couplings other than those specified above.

The Society reserves the right to increase the value of C if the shrinkage needs to absorb an extremely high pulsating torque,

T : Temperature of hub and propeller shaft material, in °C, assumed for calculation of pull-up length and push-up load

V : speed at P power, in knots

S : Continuous thrust developed for free running , in N

s_F : Safety factor against friction slip at 35°C

θ : Half taper of propeller shaft (for instance: taper = 1/15, θ =1/30)

μ : Coefficient of friction between mating surfaces

p_{35} : Surface pressure between mating surfaces, in N/mm^2, at 35°C

p_T : Surface pressure, in N/mm^2, between mating surfaces at temperature T

p_0 : Surface pressure between mating surfaces, in N/mm^2, at 0°C

p_{MAX} : Maximum permissible surface pressure, in N/mm^2, at 0°C

d_{35} : Push-up length, in mm, at 35°C

d_T : Push-up length, in mm, at temperature T

d_{MAX} : Maximum permissible pull-up length, in mm, at 0°C

W_T : Push-up load, in N, at temperature T

σ_{ID} : Equivalent uni-axial stress in the boss according to the von Mises-Hencky criterion, in N/mm^2

α_P : Coefficient of linear expansion of shaft material, in mm/(mm°C)

α_M : Coefficient of linear expansion of boss material, in mm/(mm°C)

E_P : Value of the modulus of elasticity of shaft material, in N/mm^2

E_M : Value of the modulus of elasticity of boss material, in N/mm^2

ν_P : Poisson's ratio for shaft material

ν_M : Poisson's ratio for boss material

$R_{S,MIN}$: Value of the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p\ 0,2}$), of propeller boss material, in N/mm^2.

For other symbols not defined above, see [2.2].

b) The manufacturer is to submit together with the required constructional plans specifications containing all elements necessary for verifying the shrinkage. Tests and checks deemed necessary for verifying the characteristics and integrity of the propeller material are also to be specified.

c) The formulae and other provisions below do not apply to propellers where a sleeve is introduced between shaft and boss or in the case of hollow propeller shafts. In such cases, a direct shrinkage calculation is to be submitted to the Society.

d) The taper of the propeller shaft cone is not to exceed 1/15.

e) Prior to final pull-up, the contact area between the mating surfaces is to be checked and is not to be less than 70% of the theoretical contact area (100%). Non-contact bands extending circumferentially around the boss or over the full length of the boss are not acceptable.

f) After final push-up, the propeller is to be secured by a nut on the propeller shaft. The nut is to be secured to the shaft.

g) The safety factor s_F against friction slip at 35°C is not to be less than 2,8, under the combined action of torque and propeller thrust, based on the maximum continuous power P for which classification is requested at the corresponding speed of rotation N of the propeller, plus pulsating torque due to torsionals.

h) For the oil injection method, the coefficient of friction μ is to be 0,13 in the case of bosses made of copper-based alloy and steel. For other methods, the coefficient of friction will be considered in each case by the Society.

i) The maximum equivalent uni-axial stress in the boss at 0°C, based on the von Mises-Hencky criterion, is not to exceed 70% of the minimum yield strength (R_{eH}), or 0,2% proof stress ($R_{p0,2}$), of the propeller material, based on the test piece value. For cast iron, the value of the above stress is not to exceed 30% of the nominal tensile strength.

j) For the formulae given below, the material properties indicated in the following items are to be assumed:

- Modulus of elasticity, in N/mm^2:

  Cast and forged steel: E = 206000

  Cast iron: E = 98000

  Type Cu1 and Cu2 brass: E = 108000

  Type Cu3 and Cu4 brass: E = 118000

- Poisson's ratio:

  Cast and forged steel: ν = 0,29

  Cast iron: ν = 0,26

  All copper based alloys: ν = 0,33

- Coefficient of linear expansion in mm/(mm°C)

  Cast and forged steel and cast iron: α = 12,0 10^{-6}

  All copper based alloys: α = 17,5 10^{-6}

k) For shrinkage calculation the formulae in the following items, which are valid for the ahead condition, are to be applied. They will also provide a sufficient margin of safety in the astern condition.

- Minimum required surface pressure at 35°C:

$$p_{35} = \frac{s_F S}{AB} \cdot \left[-s_F \theta + \left(\mu^2 + B \cdot \frac{F^2}{S^2} \right)^{0,5} \right]$$

  where:

  $B = \mu^2 - s_F{}^2 \theta^2$

- Corresponding minimum pull-up length at 35°C:

$$d_{35} = \frac{p_{35} d_{PM}}{2\theta} \cdot \left[\frac{1}{E_M} \cdot \left(\frac{K^2 + 1}{K^2 - 1} + \nu_M \right) + \frac{1 - \nu_P}{E_P} \right]$$

- Minimum pull-up length at temperature T (T<35°C):

$$= d_{35} + \frac{d_{PM}}{2\theta} \cdot (\alpha_M - \alpha_P) \cdot (35 -$$

- Corresponding minimum surface pressure at temperature T:

$$p_T = p_{35} \cdot \frac{d_T}{d_{35}}$$

- Minimum push-up load temperature T:

$$W_T = Ap_T \cdot (\mu + \theta)$$

- Maximum permissible surface pressure at 0°C:

$$p_{MAX} = \frac{0{,}7R_{S,MIN} \cdot (K^2 - 1)}{(3K^4 + 1)^{0,5}}$$

- Corresponding maximum permissible pull-up length at 0°C:

$$d_{MAX} = d_{35} \cdot \frac{p_{MAX}}{p_{35}}$$

- Tangential force at interface:

$$F = \frac{2000CM_T}{d_{PM}}$$

- Continuous thrust developed for free running ; if the actual value is not given, the value, in N, calculated by one of the following formulae may be considered:

$$S = 1760 \cdot \frac{P}{V}$$

$$S = 57{,}3 \cdot 10^3 \cdot \frac{P}{H \cdot N}$$

3.1.3 Circulating currents

Means are to be provided to prevent circulating electric currents from developing between the propeller and the hull. A description of the type of protection provided and its maintenance is to be kept on board.

4 Testing and certification

4.1 Material tests

4.1.1 Solid propellers

Material used for the construction of solid propellers is to be tested in accordance with the requirements of Part D of the Rules in the presence of the Surveyor.

4.1.2 Built-up propellers and controllable pitch propellers

In addition to the requirement in [4.1.1], materials for studs and for all other parts of the mechanism transmitting torque are to be tested in the presence of the Surveyor.

4.2 Testing and inspection

4.2.1 Inspection of finished propeller

Finished propellers are to be inspected at the manufacturer’s plant by the Surveyor. At least the following checks are to be carried out:

- visual examination of the entire surface of the propeller blades
- conformity to approved plans of blade profile
- liquid penetrant examination of suspected and critical parts of the propeller blade, to the satisfaction of the Surveyor.

4.2.2 Controllable pitch propellers

The complete hydraulic system for the control of the controllable pitch propeller mechanism is to be hydrotested at a pressure equal to 1,5 times the design pressure. The proper operation of the safety valve is to be tested in the presence of the Surveyor.

4.2.3 Balancing

Finished propellers are to be statically balanced. For built-up and controllable pitch propellers, the required static balancing of the complete propeller may be replaced by an individual check of blade weight and gravity centre position.

In addition, for propellers running above 500 rpm, dynamic balancing:

- is required, for cast copper alloy propellers
- may be required, for cast steel propellers.

4.3 Certification

4.3.1 Certification of propellers

Propellers having the characteristics indicated in [1.1.1] are to be individually tested and certified by the Society when required in Pt Ch.2 App.3.

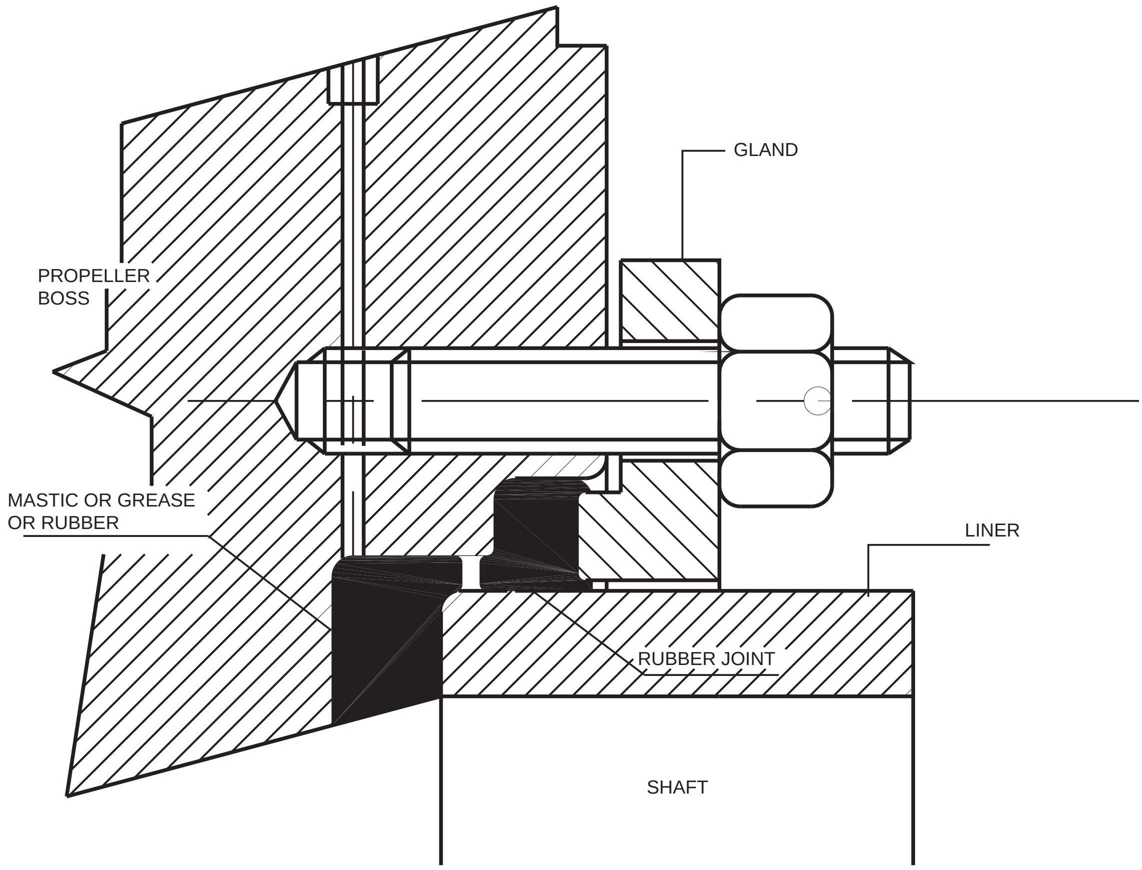
4.3.2 Mass produced propellers

Mass produced propellers may be accepted within the framework of the type approval program of the Society.

Table 4 : Controllable pitch propeller monitoring

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Main Engine			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Pump pressure	L						
Oil tank level	L						

Figure 2 : Example of sealing arrangement



SECTION 9 SHAFT VIBRATION

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the shafting of the following installations:

- propulsion systems with prime movers developing 500 kW or more
- other systems with internal combustion engines developing 500 kW or more and driving auxiliary machinery intended for essential services.

1.1.2 Exemptions

The requirements of this Section may be waived at the Society's discretion in cases where satisfactory service operation of similar installations is demonstrated or in the case of yachts classed for restricted navigation.

The requirements given in [3] may also be waived for yachts fitted with two or more independent propulsion shaft lines, when the transmitted power per shaft line is below 2000 kW.

1.2 Submission of documentation

1.2.1

As the analysis of the vibration behaviour of systems is part of their design, the relevant documentation, as listed in [3.2] is to be promptly submitted for approval.

2 Design of systems in respect of vibrations

2.1 Principle

2.1.1 General

a) Special consideration shall be given to the design, construction and installation of propulsion machinery systems so that any mode of their vibrations shall not cause undue stresses in these systems in the normal operating ranges.

b) Calculations are to be carried out for all the configurations of the system likely to have any influence on the torsional, bending or axial vibrations.

c) Where torsional and axial vibrations may be coupled (e.g. due to helical gears), the effect of such vibrations is to be investigated.

2.1.2 Vibration levels

Systems are to have torsional, bending and axial vibrations both in continuous and in transient running acceptable to the Manufacturers, and in accordance with the requirements of this section.

Where vibrations are found to exceed the limits stated in this Section, the designer or the builder of the plant is to propose corrective actions, such as:

- operating restrictions, provided that the owner is informed, or
- modification of the plant.

2.1.3 Condition of components

Systems are to be designed considering essential components in a non-ideal condition. In particular, the following conditions are to be considered:

- propulsion engine: cylinder malfunction,
- flexible coupling: possible variation of the stiffness or damping characteristics due to heating or ageing,
- vibration damper: possible variation of the damping coefficient.

2.2 Modifications of existing plants

2.2.1 Where substantial modifications of existing plants, such as:

- change of the running speed or power of the engine,
- replacement of an essential component of the system (propeller, flexible coupling, damper) by one of different characteristics, or
- connection of a new component,

are carried out, new vibration analysis is to be submitted for approval.

3 Torsional vibrations

3.1 General

3.1.1 The torsional vibration torques (or stresses) calculated in the various components of the installation are additional to those resulting from the mean power transmitted by such components. Where the scantling formulae given in Sec 7 and App 1 are applied, the vibratory torques are not to be taken into account unless otherwise stated.

3.2 Documentation to be submitted

3.2.1 Calculations

Torsional vibration calculations are to be submitted for the various configurations of the plants, showing:

- the equivalent dynamic system used for the modelling of the plant, with indication of:
  - inertia and stiffness values for all the components of the system
  - diameter and material properties of the shafts
- the natural frequencies
- the values of the vibratory torques or stresses in the components of the system for the most significant critical speeds and their analysis in respect of the Rules and other acceptance criteria
- the possible restrictions of operation of the plant.

3.2.2 Particulars to be submitted

The following particulars are to be submitted with the torsional vibration calculations:

a) for turbines, multi-engine installations or installations with power take-off systems:
   - description of the operating configurations
   - load sharing law between the various components for each configuration

b) for installations with controllable pitch propellers, the power/rotational speed values resulting from the combinator operation

c) for prime movers, the service speed range and the minimum speed at no load

d) for internal combustion engines:
   - manufacturer and type
   - nominal output and rotational speed
   - mean indicated pressure
   - number of cylinders
   - “V” angle
   - firing angles
   - bore and stroke
   - excitation data, such as the polynomial law of harmonic components of excitations
   - nominal alternating torsional stress considered for crankpin and journal

Note 1: The nominal alternating torsional stress is part of the basic data to be considered for the assessment of the crankshaft. It is defined in App 1.

e) for turbines:
   - nominal output and rotational speed
   - power / speed curve and range of operation
   - number of stages, and load sharing between the stages
   - main excitation orders for each rotating disc

- structural damping of shafts
- external damping on discs (due to the fluid)

f) for reduction or step-up gears, the speed ratio for each step

g) for flexible couplings, the data required in Note 2 of Sec 7, Tab 1

h) for torsional vibration dampers:
- the manufacturer and type
- the permissible heat dissipation
- the damping coefficient
- the inertial and stiffness properties, as applicable

i) for propellers:
- the number of blades
- the excitation and damping data, if available

j) for electric motors, generators and pumps, the drawing of the rotating parts, with their mass moment of inertia and main dimensions.

3.3 Definitions, symbols and units

3.3.1 Definitions

a) Torsional vibration stresses referred to in this Article are the stresses resulting from the alternating torque corresponding to the synthesis of the harmonic orders concerned.

b) The misfiring condition of an engine is the malfunction of one cylinder due to the absence of fuel injection (which results in a pure compression or expansion in the cylinder).

3.3.2 Symbols, units

The main symbols used in this Article are defined as follows:

τ : Torsional vibration stress, as defined in [3.3.1], in N/mm^2

τ_1 : Permissible stress due to torsional vibrations for continuous operation, in N/mm^2

τ_2 : Permissible stress due to torsional vibrations for transient running, in N/mm^2

R_m : Tensile strength of the shaft material, in N/mm^2

C_R : Material factor, equal to:

$$\frac{R_m + 160}{18}$$

d : Minimum diameter of the shaft, in mm

C_D : Size factor of the shaft, equal to:

$0,35 + 0,93\, d^{-0,2}$

N : Speed of the shaft for which the check is carried out, in rev/min

N_n : Nominal speed of the shaft, in rev/min

N_c : Critical speed, in rev/min

λ : Speed ratio, equal to N/N_n

C_λ : Speed ratio factor, equal to:
- $3 - 2\lambda^2$ for $\lambda < 0,9$
- $1,38$ for $0,9 \le \lambda \le 1,05$

C_k : Factor depending on the shaft design features given in Tab 1.

Table 1 : Values of C_k factors

Intermediate shafts						Thrust shafts external to engines		Propeller shafts	
with integral coupling flanges and straight sections	with shrink-fit couplings	with keyways, tapered connection	with keyways, cylindrical connection	with radial holes	with longitudinal slots	on both sides of thrust collar	in way of axial bearing where a roller bearing is used as a thrust bearing	for which **(5)** k = 1,22 or k = 1,26	for which **(5)** k = 1,15
1,00 **(1)**	1,00 **(2)**	0,60 **(3)**	0,45 **(3)**	0,50	0,30 **(4)**	0,85	0,85	0,55	0,80

(1) Value applicable in the case of fillet radii in accordance with the provisions of Sec 7, [2.5.1].
(2) C_K refers to the plain shaft section only. Where shafts may experience vibratory stresses close to the permissible stresses for continuous operation, an increase in diameter to the shrink fit diameter is to be provided, e.g. a diameter increase of 1 to 2 % and a blending radius as described in Sec 7, [2.2.1]
(3) Keyways are, in general, not to be used in installations with a barred speed range.
(4) C_K = 0,3 is a safe approximation within the limitations in (6) of Sec 7, Tab 2. More accurate estimate of the stress concentration factor (scf) may be determined from Note 2 of Sec 7, Tab 2 or by direct application of FE calculation. In which case:
C_K = 1,45/scf
Note that the scf is defined as the ratio between the maximum local principal stress and $3^{0,5}$ times the nominal torsional stress (determined for the bored shaft without slots).
(5) k is defined in Sec 7.
Note 1: For explanation of c_K and stress concentration factor of slots, see Sec 7, Tab 2.
Note 2: The determination of C_K factors for shafts other than those given in this table will be given special consideration by the Society.

3.4 Calculation principles

3.4.1 Method

a) Torsional vibration calculations are to be carried out using a recognised method.

b) Where the calculation method does not include harmonic synthesis, attention is to be paid to the possible superimposition of two or more harmonic orders of different vibration modes which may be present in some restricted ranges.

3.4.2 Scope of the calculations

a) Torsional vibration calculations are to be carried out considering:
- normal firing of all cylinders, and
- misfiring of one cylinder.

b) Where the torsional dynamic stiffness of the coupling depends on the transmitted torque, two calculations are to be carried out:
- one at full load
- one at the minimum load expected in service.

c) For installations with controllable pitch propellers, two calculations are to be carried out:
- one for full pitch condition
- one for zero pitch condition.

d) The calculations are to take into account all possible sources of excitation. Electrical sources of excitations, such as static frequency converters, are to be detailed.

e) The natural frequencies are to be considered up to a value corresponding to 15 times the maximum service speed. Therefore, the excitations are to include harmonic orders up to the fifteenth.

3.4.3 Criteria for acceptance of the torsional vibration loads under normal firing conditions

a) Torsional vibration stresses in the various shafts are not to exceed the limits defined in [3.5]. Higher limits calculated by an alternative method may be considered, subject to special examination by the Society.

The limit for continuous running τ_1 may be exceeded only in the case of transient running in restricted speed ranges, which are defined in [3.5.5]. In no case are the torsional vibration stresses to exceed the limit for transient running τ_2.

Propulsion systems are to be capable of running continuously without restrictions at least within the speed range between 0,8 N_n and 1,05 N_n. Transient running may be considered only in restricted speed ranges for speed ratios $\lambda \leq 0,8$.

Auxiliary machinery is to be capable of running continuously without restrictions at least within the range between 0,95 N_n and 1,1 N_n. Transient running may be considered only in restricted speed ranges for speed ratios $\lambda \leq 0,95$.

b) Torsional vibration levels in other components are to comply with the provisions of [3.6].

3.4.4 Criteria for acceptance of torsional vibration loads under misfiring conditions

a) The provisions of [3.4.3] related to normal firing conditions also apply to misfiring conditions except that restricted speed ranges are also acceptable for l > 0,8.

The restricted speed ranges in one-cylinder misfiring condition of single propulsion engine s are to enable safe navigation.

b) Where calculations show that the limits imposed for certain components may be exceeded under misfiring conditions, a suitable device is to be fitted to indicate the occurence of such conditions.

3.5 Permissible limits for torsional vibration stresses in crankshaft, propulsion shafting and other transmission shafting

3.5.1 General

a) The limits provided below apply to steel shafts. For shafts made of other material, the permissible limits for torsional vibration stresses will be determined by the Society after examination of the results of fatigue tests carried out on the material concerned.

b) These limits apply to the torsional vibration stresses as defined in [3.3.1]. They relate to the shaft minimum section, without taking account of the possible stress concentrations.

3.5.2 Crankshaft

a) Where the crankshaft has been designed in accordance with Pt C, Ch 1, App 1 of Tasneef Rules for the Classification of Ships, the torsional vibration stresses in any point of the crankshaft are not exceed the following limits:

- $\tau_1 = \tau_N$ for continuous running
- $\tau_2 = 1,7\ \tau_N$ for transient running,

where τ_N is the nominal alternating torsional stress on which the crankshaft scantling is based (see [3.2.2], Note 1).

b) Where the crankshaft has not been designed in accordance with Pt C, Ch 1, App 1 of Tasneef Rules for the Classification of Ships, the torsional vibration stresses in any point of the crankshaft are not to exceed the following limits:

- $\tau_1 = 0,55 . C_R . C_D . C_\lambda$ for continuous running
- $\tau_2 = 2,3\ \tau_1$ for transient running.

3.5.3 Intermediate shafts, thrust shafts and propeller shafts

The torsional vibration stresses in any intermediate, thrust and propeller shafts are not to exceed the following limits:

- $\tau_1 = C_R . C_k . C_D . C_\lambda$ for continuous running
- $\tau_2 = 1,7\ \tau_1 . C_k^{-0,5}$ for steady state conditions within barred speed range.

Note 1: For intermediate, thrust and propeller shafts, the material factor C_R is not to be taken as greater than 42,2.

3.5.4 Transmission shafting for generating sets and other auxiliary machinery

The torsional vibration stresses in the transmission shafting for generating sets and other auxiliary machinery, such as pumps or compressors, are not to exceed the following limits:

- $\tau_1 = 0,90 . C_R . C_D$ for continuous running
- $\tau_2 = 5,4\ \tau_1$ for transient running.

3.5.5 Restricted speed ranges

a) Where the stress amplitudes exceed the limiting values of τ_1 for continuous operation, including one cylinder misfiring conditions, restricted speed ranges are to be imposed which are to be passed through rapidly;

b) restricted speed ranges in one-cylinder misfiring conditions of single propulsion engine s are to enable safe navigation;

c) the barred speed range is to cover all speeds where the acceptance limits (τ_1) are exceeded. For controllable pitch propellers with the possibility of individual pitch and speed control, both full and zero pitch conditions are to be considered.

Additionally, the tachometer tolerance is to be added. At each end of the barred speed range the engine is to be stable in operation;

d) the limits of the restricted speed range related to a critical speed N_c are to be calculated in accordance with the following formula:

$$\frac{16 \cdot N_c}{18 - \lambda} \leq N \leq \frac{(18 - \lambda) \cdot N_c}{16}$$

e) where the resonance curve of a critical speed is obtained from torsional vibration measurements, the restricted speed range may be established considering the speeds for which the stress limit for continuous running τ_1 is exceeded;

f) where restricted speed ranges are imposed, they are to be crossed out on the tachometers and an instruction plate is to be fitted at the control stations indicating that:
- the continuous operation of the engine within the considered speed range is not permitted
- this speed range is to be passed through rapidly.

3.6 Permissible vibration levels in components other than shafts

3.6.1 Gears

a) The torsional vibration torque in any gear step is not to exceed 30% of the torque corresponding to the approved rating throughout the service speed range.

Where the torque transmitted at nominal speed is less than that corresponding to the approved rating, higher torsional vibration torques may be accepted, subject to special consideration by the Society.

b) Gear hammering induced by torsional vibration torque reversal is not permitted throughout the service speed range, except during transient running at speed ratios $\lambda \leq 0,3$.

Where calculations show the existence of torsional vibration torque reversals for speed ratios $\lambda > 0,3$, the corresponding speed ranges are to be identified by appropriate investigations during sea trials and considered as restricted speed ranges in accordance with [3.5.5].

3.6.2 Generators

a) In the case of alternating current generators, the torsional vibration amplitude at the rotor is not to exceed ±2,5 electrical degrees at service rotational speed under full load working conditions.

b) Vibratory inertia torques due to torsional vibrations and imposed on the rotating parts of the generator are not to exceed the values M_A, in N.m, calculated by the following formulae, as appropriate:
- for $0,95 \leq \lambda \leq 1,1$: $M_A = \pm 2,5\ M_T$
- for $\lambda \leq 0,95$: $M_A = \pm 6\ M_T$,

where:

M_T : Mean torque transmitted by the engine under full load running conditions, in N.m

Note 1: In the case of two or more generators driven by the same engine, the portion of M_T transmitted to each generator is to be considered.

λ : Speed ratio defined in [3.3.2].

3.6.3 Flexible couplings

a) Flexible couplings are to be capable of withstanding the mean transmitted torque and the torsional vibration torque throughout the service speed range, without exceeding the limits for continuous operation imposed by the manufacturer (permissible vibratory torque and power loss).

Where such limits are exceeded under misfiring conditions, appropriate restrictions of power or speed are to be established.

b) Flexible couplings fitted in generating sets are also to be capable of withstanding the torques and twist angles arising from transient criticals and short-circuit currents.

3.6.4 Dampers

a) Torsional vibration dampers are to be such that the permissible power loss recommended by the manufacturer is not exceeded throughout the service speed range.

b) Dampers for which a failure may lead to a significant vibration overload of the installation will be the subject of special consideration.

3.7 Torsional vibration measurements

3.7.1 General

a) The Society may require torsional vibration measurements to be carried out under its supervision in the following cases:

- where the calculations indicate the possibility of dangerous critical speeds in the operating speed range,
- where doubts arise as to the actual stress amplitudes or critical speed location, or
- where restricted speed ranges need to be verified.

b) Where measurements are required, a comprehensive report including the analysis of the results is to be submitted to the Society.

3.7.2 Method of measurement

When measurements are required, the method of measurement is to be submitted to the Society for approval. The type of measuring equipment and the location of the measurement points are to be specified.

4 Lateral vibrations of main propulsion systems

4.1 General

4.1.1

Main propulsion systems are to be free from excessive lateral vibration throughout the working speed range.

Failing this, provision is to be made to limit the vibration amplitudes by modifying the dynamic system or restricted speed ranges are to be imposed in the corresponding regions of speeds.

4.2 Calculations and measurements on board

4.2.1

Unless previous experience of similar installations proves it to be unnecessary, the Society, on the basis of the characteristics of the main propulsion system concerned, reserves the right to require lateral vibration calculations to be submitted and/or measurements on board to be taken using an apparatus accepted by the Society.

5 Axial vibrations of main propulsion systems

5.1 General

5.1.1

Main propulsion systems are to be free from excessive axial vibrations throughout the working speed range.

Failing this, provision is to be made to limit the vibration amplitudes by modifying the dynamic system, or restricted speed ranges are to be imposed in the corresponding regions of speeds.

5.2 Calculations and measurements on board

5.2.1

Unless previous experience of similar installations proves it to be unnecessary, the Society, on the basis of the characteristics of the main propulsion system concerned, reserves the right to require axial vibration calculations to be submitted and/or measurements on board to be taken using an apparatus accepted by the Society.

SECTION 10 PIPING SYSTEM

1 General

1.1 Application

1.1.1

a) General requirements applying to all piping systems are contained in:
- [2] for their design and construction
- [3] for the welding of steel pipes
- [4] for the bending of pipes
- [5] for their arrangement and installation
- [17] for their certification, inspection and testing.

b) Specific requirements for piping systems and machinery piping systems are given in Articles [6] to [16].

[17] is applicable when requested in accordance with the relevant Table of Pt A, Ch 2, App 3.

1.2 Documentation to be submitted

1.2.1 Documents

The documents listed in Tab 1 are to be submitted.

1.2.2 Additional information

The information listed in Tab 2 is also to be submitted.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Document **(2)**
1	A	Drawing showing the arrangement of the sea chests and side valves
2	A	Diagram of the bilge and ballast systems (in and outside machinery spaces)
3	A	Specification of the central priming system intended for bilge pumps, when provided
4	A	Diagram of the scuppers and sanitary discharge systems
5	A	Diagram of the air, sounding and overflow systems
6	A	Diagram of cooling systems (sea water and fresh water)
7	A	Diagram of fuel oil system
8	A	Drawings of the fuel oil tanks not forming part of the yacht‘s structure
9	A	Diagram of the lubricating oil system
10	A	Diagram of the hydraulic systems intended for essential services or located in machinery spaces
11	A	Diagram of the compressed air system
12	A	Diagram of the hydraulic and pneumatic remote control systems
13	A	Diagram of the remote level gauging system
14	I	Diagram of the exhaust gas system
15	A	Diagram of drip trays and gutterway draining system
16	A	Drawings and specification of valves and accessories, where required in [2.6]

(1) A = to be submitted for approval;
I = to be submitted for information.

(2) Diagrams are also to include, where applicable, the (local and remote) control and monitoring systems and automation systems.

Table 2 : Information to be submitted

No.	I/A **(1)**	Document
1	I	Nature, service temperature and pressure of the fluids
2	A	Material, external diameter and wall thickness of the pipes
3	A	Type of the connections between pipe lengths, including details of the weldings, where provided
4	A	Material, type and size of the accessories
5	A	Capacity, prime mover and, when requested, location of the pumps
6	A	For plastic pipes: • the chemical composition • the physical and mechanical characteristics in function of temperature • the characteristics of inflammability and fire resistance • the resistance to the products intended to be conveyed
7	A	For fuel oil system : the diagram of the fuel oil system is to indicate the location of sampling points or a dedicated diagram of sampling points is to be presented together with the documentation relevant to the fuel system

(1) A = to be submitted for approval;
I = to be submitted for information.

1.3 Definitions

1.3.1 Piping and piping systems *(1/1/2025)*

a) Piping includes pipes and their connections, flexible hoses and expansion joints, valves and their actuating systems, other accessories (filters, level gauges, etc.) and pump casings.

b) Piping systems include piping and all the interfacing equipment such as tanks, pressure vessels, heat exchangers, pumps and centrifugal purifiers, but do not include turbines, internal combustion engines and reduction gears.

Note 1: The equipment other than piping is to be designed in accordance with the relevant Sections of Chapter 1.

1.3.2 Design pressure

a) The design pressure of a piping system is the pressure considered by the manufacturer to determine the scantling of the system components. It is not to be taken less than the maximum working pressure expected in this system or the highest setting pressure of any safety valve or relief device, whichever is the greater.

b) The design pressure of a piping system located on the low pressure side of a pressure reducing valve where no safety valve is provided is not to be less than the maximum pressure on the high pressure side of the pressure reducing valve.

c) The design pressure of a piping system located on the delivery side of a pump or a compressor is not to be less than the setting pressure of the safety valve for displacement pumps or the maximum pressure resulting from the operating (head-capacity) curve for centrifugal pumps, whichever is the greater.

1.3.3 Design temperature

The design temperature of a piping system is the maximum temperature of the medium inside the system.

1.3.4 Flammable oils

Flammable oils include fuel oils, lubricating oils, thermal oils and hydraulic oils (having flashpoint lower than 150°C).

1.4 Symbols and units

1.4.1 The following symbols and related units are commonly used in this Section. Additional symbols, related to some formulae indicated in this Section, are listed wherever it is necessary.

p : Design pressure, in MPa

T : Design temperature, in °C

t : Rule required minimum thickness, in mm

D : Pipe external diameter, in mm.

1.5 Class of piping systems

1.5.1 Purpose of the classes of piping systems

Piping systems are subdivided into three classes, denoted as class I, class II and class III, for the purpose of acceptance of materials, selection of joints, heat treatment, welding, pressure testing and the certification of fittings.

1.5.2 Definitions of the classes of piping systems

a) Classes I, II and III are defined in Tab 3

b) Fluids for refrigerating plants are not covered by Tab 3.

2 General requirements for design and construction

2.1 Materials

2.1.1 General

Materials to be used in piping systems are to be suitable for the medium and the service for which the piping is intended.

2.1.2 Use of metallic materials

a) Metallic materials are to be used in accordance with Tab 4.

b) Materials for class I and class II piping systems are to be manufactured and tested in accordance with the appropriate requirements of Part D.

c) Materials for class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable national or international standards or specifications.

d) Mechanical characteristics required for metallic materials are specified in Part D.

2.1.3 Use of plastics

a) Plastics may be used for piping systems belonging to class III in accordance with App 3. The use of plastics for other systems or in other conditions will be given special consideration.

b) Plastics intended for piping systems dealt with in this Section are to be of a type approved by the Society.

2.2 Thickness of pressure piping

2.2.1 Calculation of the thickness of pressure pipes

a) The thickness t, in mm, of pressure pipes is to be determined by the following formula but, in any case, is not to be less than the minimum thickness given in Tab 5 to Tab 8.

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}}$$

where:

t_0 : Coefficient, in mm, equal to

$$t_0 = \frac{p \cdot D}{2Ke + p}$$

with:

p and D: as defined in [1.4.1],

K : Permissible stress defined in [2.2.2],

e : Weld efficiency factor to be:

- equal to 1 for seamless pipes and pipes fabricated according to a welding procedure approved by the Society,
- specially considered by the Society for other welded pipes, depending on the service and the manufacture procedure.

b : Thickness reduction due to bending defined in [2.2.3], in mm

c : Corrosion allowance defined in [2.2.4], in mm a : Negative manufacturing tolerance percentage:

- equal to 10 for copper and copper alloy pipes, cold drawn seamless steel pipes and steel pipes fabricated according to a welding procedure approved by the Society,
- equal to 12,5 for hot laminated seamless steel pipes,
- subject to special consideration by the Society in other cases.

b) The thickness thus determined does not take into account the particular loads to which pipes may be subjected. Attention is to be drawn in particular to the case of high temperature and low temperature pipes.

Table 3 : Class of piping systems *(1/1/2025)*

Media conveyed by the piping system	CLASS I	CLASS II	CLASS III
Fuel oil **(1)**	p > 1,6 or T > 150	other **(2)**	p ≤ 0,7 and T ≤ 60
Flammable Hydraulic oil **(5)**	p>1,6 or T>150	other **(2)**	p ≤ 0,7 and T≤60
Lubricating oil	p> 1,6 or T > 150	other **(2)**	p ≤ 0,7 and T ≤ 60
Other flammable media: • heated above flashpoint, or • having flashpoint <60°C and liquefied gas	without special safeguards **(3)**	with special safeguards **(3)**	
Toxic media	irrespective of p, T		
Corrosive media	without special safeguards **(3)**	with special safeguards **(3)**	
Air, gases, water, non-flammable hydraulic oil **(4)**	p > 4 or T > 300	other **(2)**	p ≤ 1,6 and T ≤ 200
Open-ended pipes (drains, overflows, vents, exhaust gas lines)			irrespective of T

(1) Valves under static pressure on fuel oil tanks belong to class II.
(2) Pressure and temperature conditions other than those required for class I and class III.
(3) Safeguards for reducing the possibility of leakage and limiting its consequences, e.g. pipes led in positions where leakage of internal fluids will not cause a potential hazard or damage to surrounding areas which may include the use of pipe ducts, shielding, screening, etc.
(4) Valves and fittings fitted on the side and collision bulkhead belong to class II.
(5) Steering gear piping belongs to class I irrespective of p and T
Note 1: p : Design pressure, as defined in [1.3.2], in MPa.
Note 2: T : Design temperature, as defined in [1.3.3], in °C.

Table 4 : Conditions of use of metallic materials in piping systems *(1/1/2025)*

Material	Allowable classes	Maximum design temperature (°C) **(1)**	Particular conditions of use
Carbon and carbon-manganese steels	III, II, I	400 **(2)**	Class I and II pipes are to be seamless drawn pipes **(3)**
Copper and aluminium brass	III, II, I	200	**(4)**
Copper-nickel	III, II, I	300	

(1) Maximum design temperature is not to exceed that assigned to the class of piping.
(2) Higher temperatures may be accepted if metallurgical behaviour and time dependent strength (ultimate tensile strength after 100000 hours) are in accordance with national or international standards or specifications and if such values are guaranteed by the steel manufacturer.
(3) Pipes fabricated by a welding procedure approved by the Society may also be used.
(4) Pipes made of copper and copper alloys are to be seamless.
(5) Use of grey cast iron is not allowed when the design pressure exceeds 1,3 MPa.
(6) Accessories of aluminium or aluminium alloys intended for flammable oil systems may be accepted subject to the satisfactory result of an endurance flame test to be carried out according to the "Rules for the type approval of flexible hoses and expansion joints" issued by the Society.

Material	Allowable classes	Maximum design temperature (°C) **(1)**	Particular conditions of use
Special high temperature resistant bronze	III, II, I	260	
Stainless steel	III, II, I	300	Austenitic stainless steel is not recommended for sea water systems
Spheroidal graphite cast iron	III, II	350	• Spheroidal cast iron of the ferritic type according to the material rules of the Society may be accepted for bilge, and ballast piping • The use of this material for pipes, valves and fittings for other services, in principle Classes II and III, will be subject to special consideration • Spheroidal cast iron pipes and valves fitted on yacht's side should have specified properties to the Society's satisfaction, • Minimum elongation is not to be less than 12% on a gauge length of $5,65.S^{0,5}$, where S is the actual cross-sectional area of the test piece
Grey cast iron	III II **(5)**	220	Grey cast iron is not to be used for the following systems: • piping systems subject to shocks, high stresses and vibrations • bilge lines in tanks • parts of scuppers and sanitary discharge systems located next to the hull below the freeboard deck or for passengers s below the bulkhead deck • side valves and fittings • valves fitted on the collision bulkhead • valves fitted to fuel oil and lubricating oil tanks under static pressure head • class II fuel oil systems
Aluminium and aluminium alloys	III, II, I **(6)**	200	Aluminium and aluminium alloys are not to be used on the following systems: • flammable oil systems **(6)** • sounding and air pipes of fuel oil tanks • fire-extinguishing systems • scuppers and overboard discharges except for pipes led to the bottoms or to the shell above the freeboard deck or fitted at their upper end with closing means operated from a position above the freeboard deck

(1) Maximum design temperature is not to exceed that assigned to the class of piping.
(2) Higher temperatures may be accepted if metallurgical behaviour and time dependent strength (ultimate tensile strength after 100000 hours) are in accordance with national or international standards or specifications and if such values are guaranteed by the steel manufacturer.
(3) Pipes fabricated by a welding procedure approved by the Society may also be used.
(4) Pipes made of copper and copper alloys are to be seamless.
(5) Use of grey cast iron is not allowed when the design pressure exceeds 1,3 MPa.
(6) Accessories of aluminium or aluminium alloys intended for flammable oil systems may be accepted subject to the satisfactory result of an endurance flame test to be carried out according to the "Rules for the type approval of flexible hoses and expansion joints" issued by the Society.

Table 5 : Minimum wall thickness for steel pipes

External diameter (mm)	Minimum nominal wall thickness (mm)		Minimum reinforced wall thickness (mm) **(2)**	Minimum extra-reinforced wall thickness (mm) **(3)**
	Sea water pipes, bilge and ballast systems **(1)**	Other piping systems **(1)**		
10,2 - 12,0	-	1,6	-	-
13,5 - 19,3	-	1,8	-	-
20,0	-	2,0	-	-
21,3 - 25,0	3,2	2,0	-	-
26,9 - 33,7	3,2	2,0	-	-
38,0 - 44,5	3,6	2,0	6,3	7,6

External diameter (mm)	Minimum nominal wall thickness (mm)		Minimum reinforced wall thickness (mm) **(2)**	Minimum extra-reinforced wall thickness (mm) **(3)**
	Sea water pipes, bilge and ballast systems **(1)**	Other piping systems **(1)**		
48,3	3,6	2,3	6,3	7,6
51,0 - 63,5	4,0	2,3	6,3	7,6
70,0	4,0	2,6	6,3	7,6
76,1 - 82,5	4,5	2,6	6,3	7,6
88,9 - 108,0	4,5	2,9	7,1	7,8
114,3 - 127,0	4,5	3,2	8,0	8,8
133,0 - 139,7	4,5	3,6	8,0	9,5
152,4 - 168,3	4,5	4,0	8,8	11,0
177,8	5,0	4,5	8,8	12,7
193,7	5,4	4,5	8,8	12,7
219,1	5,9	4,5	8,8	12,7
244,5 - 273,0	6,3	5,0	8,8	12,7
298,5 - 368,0	6,3	5,6	8,8	12,7
406,4 - 457,2	6,3	6,3	8,8	12,7

(1) Attention is drawn to the special requirements regarding:
- bilge and ballast systems
- scupper and discharge pipes
- sounding, air and overflow pipes
- ventilation systems

(2) Reinforced wall thickness applies to bilge, ballast, vent, overflow and sounding pipes passing through fuel tank and bilge, vent, overflow, sounding and fuel pipes passing through ballast tanks.

(3) Extra-reinforced wall thickness applies to pipes connected to the shell.

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.

Note 2: Where pipes and any integral pipe joints are protected against corrosion by means coating, lining, etc. at the discretion of the Society, thickness may be reduced by not more than 1 mm.

Note 3: The thickness of threaded pipes is to be measured at the bottom of the thread.

Note 4: The minimum thickness listed in this table is the nominal wall thickness and no allowance is required for negative tolerance or reduction in thickness due to bending.

Note 5: The minimum wall thickness for pipes larger than 450 mm nominal size is to be in accordance with a national or international standard and in any case not less than the minimum wall thickness of the appropriate column indicated for 450 mm pipe size.

Table 6 : Minimum wall thickness for copper and copper alloy pipes

External diameter (mm)	Minimum wall thickness (mm)	
	Copper	Copper alloy
8 - 10	1,0	0,8
12 - 20	1,2	1,0
25 - 44,5	1,5	1,2
50 - 76,1	2,0	1,5
88,9 - 108	2,5	2,0
133 - 159	3,0	2,5
193,7 - 267	3,5	3,0
273 - 457,2	4,0	3,5
470	4,0	3,5

External diameter (mm)	Minimum wall thickness (mm)	
	Copper	Copper alloy
508	4,5	4,0
Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.		

Table 7 : Minimum wall thickness for stainless steel pipes

External diameter (mm)	Minimum wall thickness (mm)
up to 17,2	1,0
up to 48,3	1,6
up to 88,9	2,0
up to 168,3	2,3
up to 219,1	2,6
up to 273,0	2,9
up to 406,4	3,6
over 406,4	4
Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards.	

Table 8 : Minimum wall thickness for aluminium and aluminium alloy pipes

External diameter (mm)	Minimum wall thickness (mm)
0 - 10	1,5
12 - 38	2,0
43 - 57	2,5
76 - 89	3,0
108 - 133	4,0
159 - 194	4,5
219 - 273	5,0
above 273	5,5
Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards. **Note 2:** For sea water pipes, the minimum thickness is not to be less than 5 mm.	

2.2.2 Permissible stress

a) The permissible stress K is given:
   - in Tab 9 for carbon and carbon-manganese steel pipes,
   - in Tab 10 for alloy steel pipes, and
   - in Tab 11 for copper and copper alloy pipes,

   as a function of the temperature. Intermediate values may be obtained by interpolation.

b) Where, for carbon steel and alloy steel pipes, the value of the permissible stress K is not given in Tab 9 or Tab 10, it is to be taken equal to the lowest of the following values:

$$\frac{R_{m,20}}{2,7} \qquad \frac{R_e}{A} \qquad \frac{S_R}{A} \qquad S$$

where:

$R_{m,20}$: Minimum tensile strength of the material at ambient temperature (20°C), in N/mm^2

R_e : Minimum yield strength or 0,2% proof stress at the design temperature, in N/mm^2

S_R : Average stress to produce rupture in 100000 h at design temperature, in N/mm^2

S : Average stress to produce 1% creep in 100000 h at design temperature, in N/mm^2

A : Safety factor to be taken equal to:
- 1,6 when R_e and S_R values result from tests attended by the Society,
- 1,8 otherwise.

c) The permissible stress values adopted for materials other than carbon steel, alloy steel, copper and copper alloy will be specially considered by the Society.

2.2.3 Thickness reduction due to bending

a) Unless otherwise justified, the thickness reduction b due to bending is to be determined by the following formula:

$$b = \frac{Dt_0}{2,5\rho}$$

where:

ρ : Bending radius measured on the centre line of the pipe, in mm

D : as defined in [1.4.1]

t_0 : as defined in [2.2.1].

b) When the bending radius is not given, the thickness reduction is to be taken equal to:

$$\frac{t_0}{10}$$

c) For straight pipes, the thickness reduction is to be taken equal to 0.

2.2.4 Corrosion allowance

The values of corrosion allowance c are given for steel pipes in Tab 12 and for non-ferrous metallic pipes in Tab 13.

Table 9 : Permissible stresses for carbon and carbon-manganese steel pipes

Specified minimum tensile strength (N/mm²)	Design temperature (°C)												
	≤50	100	150	200	250	300	350	400	410	420	430	440	450
320	107	105	99	92	78	62	57	55	55	54	54	54	49
360	120	117	110	103	91	76	69	68	68	68	64	56	49
410	136	131	124	117	106	93	86	84	79	71	64	56	49
460	151	146	139	132	122	111	101	99	98	85	73	62	53
490	160	156	148	141	131	121	111	109	98	85	73	62	53

Table 10 : Permissible stresses for alloy steel pipes

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		≤50	100	200	300	350	400	440	450	460	470
1Cr1/2Mo	440	159	150	137	114	106	102	101	101	100	99
2 1/4Cr1Mo annealed	410	76	67	57	50	47	45	44	43	43	42
2 1/4Cr1Mo normalised and tempered below 750°C	490	167	163	153	144	140	136	130	128	127	116
2 1/4Cr1Mo normalised and tempered above 750°C	490	167	163	153	144	140	136	130	122	114	105
1/2Cr 1/2Mo 1/4V	460	166	162	147	120	115	111	106	105	103	102

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		480	490	500	510	520	530	540	550	560	570
1Cr1/2Mo	440	98	97	91	76	62	51	42	34	27	22
2 1/4Cr1Mo annealed	410	42	42	41	41	41	40	40	40	37	32

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		480	490	500	510	520	530	540	550	560	570
2 1/4Cr1Mo normalised and tempered below 750°C	490	106	96	86	79	67	58	49	43	37	32
2 1/4Cr1Mo normalised and tempered above 750°C	490	96	88	79	72	64	56	49	43	37	32
1/2Cr 1/2Mo 1/4V	460	101	99	97	94	82	72	62	53	45	37

Table 11 : Permissible stresses for copper and copper alloy pipes

Material (annealed)	Specified minimum tensile strength (N/mm²)	Design temperature (°C)										
		≤50	75	100	125	150	175	200	225	250	275	300
Copper	215	41	41	40	40	34	27,5	18,5				
Aluminium brass	325	78	78	78	78	78	51	24,5				
Copper-nickel 95/5 and 90/10	275	68	68	67	65,5	64	62	59	56	52	48	44
Copper-nickel 70/30	365	81	79	77	75	73	71	69	67	65,5	64	62

Table 12 : Corrosion allowance for steel pipes

Piping system	Corrosion allowance (mm)
Compressed air	1,0
Hydraulic oil	0,3
Lubricating oil	0,3
Fuel oil	1,0
Fresh water	0,8
Sea water	3,0
Refrigerants referred to in Section 13	0,3
Note 1: For pipes passing through tanks, an additional corrosion allowance is to be considered in order to account for the external corrosion. **Note 2:** The corrosion allowance may be reduced where pipes and any integral pipe joints are protected against corrosion by means of coating, lining, etc. **Note 3:** When the corrosion resistance of alloy steels is adequately demonstrated, the corrosion allowance may be disregarded.	

Table 13 : Corrosion allowance for non-ferrous metal pipes

Piping material **(1)**	Corrosion allowance (mm) **(2)**
Copper	0,8
Brass	0,8
Copper-tin alloys	0,8
Copper-nickel alloys with less than 10% of Ni	0,8
Copper-nickel alloys with at least 10% of Ni	0,5
Aluminium and aluminium alloys	0,5
(1) The corrosion allowance for other materials will be specially considered by the Society. Where their resistance to corrosion is adequately demonstrated, the corrosion allowance may be disregarded. **(2)** In cases of media with high corrosive action, a higher corrosion allowance may be required by the Society.	

2.2.5 Tees

As well as complying with the provisions of [2.2.1] to [2.2.4] above, the thickness t_T of pipes on which a branch is welded to form a Tee is not to be less than that given by the following formula:

$$t_T = \left(1 + \frac{D_1}{D}\right) \cdot t_0$$

where:

D_1 : External diameter of the branch pipe

D : as defined in [1.4.1]

t_0 : as defined in [2.2.1]

Note 1: This requirement may be dispensed with for Tees provided with a reinforcement or extruded.

2.3 Junction of pipes

2.3.1 General

a) The number of joints in flammable oil piping systems is to be kept to the minimum necessary for mounting and dismantling purposes.

b) Direct connections of pipe lengths may be made by direct welding, flanges, threaded joints or mechanical joints, and are to be to a recognised standard or of a design proven to be suitable for the intended purpose and acceptable to the Society.

The expression "mechanical joints" means devices intended for direct connection of pipe lengths other than by welding, flanges or threaded joints described in [2.3.2], [2.3.3] and [2.3.4] below.

c) The gaskets and packings used for the joints are to suit the design pressure, the design temperature and the nature of the fluids conveyed.

d) The junction between plastic pipes is to comply with App 3.

2.3.2 Welded connections

a) Welding and non destructive testing of welds are to be carried out in accordance with [3]. Welded joints are to be used in accordance with Tab 15.

b) Butt-welded joints are to be of full penetration type with or without special provision for a high quality of root side.

The expression "special provision for a high quality of root side" means that butt welds were accomplished as double welded or by use of a backing ring or inert gas back-up on first pass, or other similar methods accepted by the Society.

Butt welded joints with special provision for a high quality of root side may be used for piping of any Class and any outside diameter.

c) Slip-on sleeve and socket welded joints are to have sleeves, sockets and weldments of adequate dimensions conforming to a standard recognised by the Society.

2.3.3 Flange connections

a) The dimensions and configuration of flanges and bolts are to be chosen in accordance with a Standard recognised by the Society. This standard is to cover the design pressure and design temperature of the piping system.

b) For non-standard flanges the dimensions of flanges and bolts are subject to special consideration by the Society.

c) Flange material is to be suitable for the nature and temperature of the fluid, as well as for the material of the pipe on which the flange is to be attached.

d) Flanges are to be attached to the pipes by welding or screwing in accordance with one of the designs shown in Fig 1.

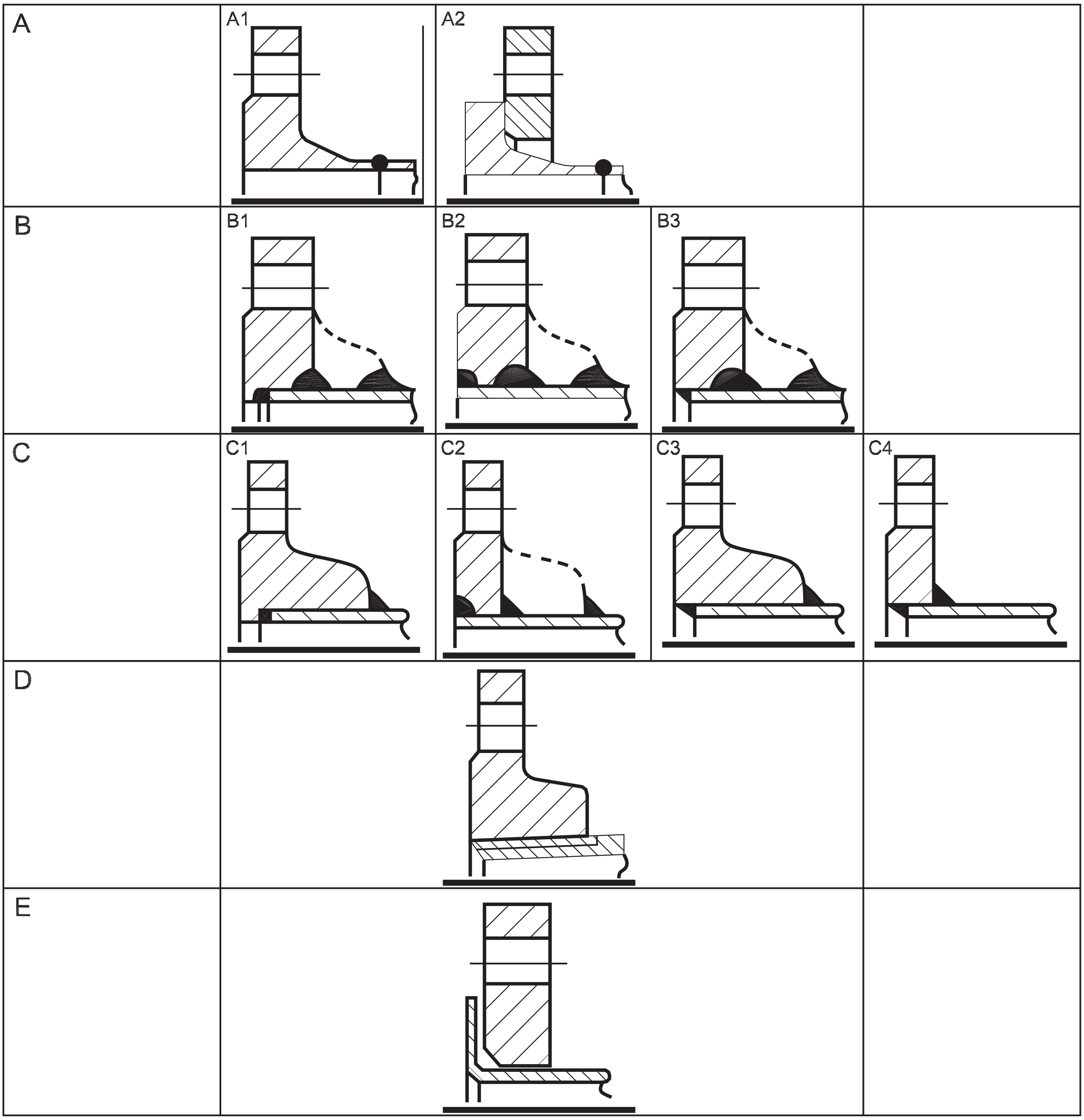
Permitted applications are indicated in Tab 14. However the Society may accept flange attachments in accordance with national or international standards that are applicable to the piping system and recognise the boundary fluids, design pressure and temperature conditions, external or cyclic loading and location.

2.3.4 Slip-on threaded joints

Slip-on threaded joints having pipe threads where pressure-tight joints are made on the threads with parallel or tapered threads, are to comply with requirements of a recognised national or international standard.

Slip-on threaded joints are to be used according to Tab 15.

Figure 1 : Types of metallic flange connections



Note 1: For type D, the pipe and flange are to be screwed with a tapered thread and the diameter of the screw portion of the pipe over the thread is not to be appreciably less than the outside diameter of the unthreaded pipe. For certain types of thread, after the flange has been screwed hard home, the pipe is to be expanded into the flange.

Note 2: For connections (C1), (C2), (C3) and (C4) the leg length of the fillet weld is to be in general equal to 1,5 times the pipe thickness but in no case is to be less than 6 mm.

Note 3: For connections (B1), (B2), (B3) and (C2) the dimension of the groove penetration in the flange is to be in general equal to the pipe thickness but in no case is to be less than 5 mm.

Table 14 : Types of flange connections required in relation to the class of piping and the type of media conveyed (1)

Class of piping ® Type of media conveyed ¯	Class I	Class II	Class III
Toxic or corrosive media, flammable liquid media or liquefied gases	(A1)-(A2)-(B1)-(B2)-(B3) **(2) (3)**	(A1)-(A2)-(B1)-(B2)-(B3)-(C1)- (C2)-(C3) **(2)**	(A1)-(A2)-(B1)-(B2)-(B3) - (C1)- (C2)-(C3) **(2)**
Lubricating and fuel oil	(A1)-(A2)-(B1)-(B2)-(B3)	(A1)-(A2)-(B1)-(B2)-(B3) - (C1)- (C2)-(C3)-(C4) (4)	(A1)-(A2)-(B1)-(B2)-(B3) - (C1)- (C2)-(C3)-(C4)
Other media, including water, air, gases, refrigerants, non flammable hydraulic oil (7)	(A1)-(A2)-(B1)-(B2)-(B3) (5)	(A1)-(A2)-(B1)-(B2)-(B3) - (C1)- (C2)-(C3)-(C4)-(D) (6)	(A1)-(A2)-(B1)-(B2)-(B3) - (C1)- (C2)-(C3)-(C4)-(D)-(E) (8)

(1) The types of flange connections given in the Table are those shown in Fig 1.
(2) Only type (A1) and (A2) flange connections are to be adopted for piping conveying flammable, toxic or corrosive liquid media having a design pressure **p** (see item [1.3.2]) higher than 1 N/mm^2.
(3) For piping having a nominal diameter equal to or greater than 150 mm, only type (A1) and (A2) flange connections are to be adopted.
(4) Flange connections of type (C4) are only acceptable for piping having a design pressure **p** less than 1,6 N/mm^2 and design temperature **T** (see item [1.3.3]) less than 150°C.
(5) Only type (A1) and (A2) flange connections are to be adopted for piping having a design temperature **T** higher than 400°C.
(6) Flange connections of types (D) and (C4) are not acceptable for piping having a design temperature **T** exceeding 250°C.
(7) For piping of hydraulic power plants of steering gears, only flange connections of types required for Class I piping are to be used.
(8) Flange connections of type (E) are only acceptable for water piping and open ended lines (e.g. drain, overflow, air vent piping, etc.).

Table 15 : Use of welded and threaded metallic joints in piping systems

	Permitted classes of piping	Restrictions of use
Butt-welded joint **(1)**	III, II, I	no restrictions
Slip-on sleeve joint **(2)**	III	no restrictions
Sleeve threaded joint (tapered thread) **(3)**	I	not allowed for: • pipes with outside diameter of more than 33,7 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.
	II, III	not allowed for: • pipes with outside diameter of more than 60,3 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.
Sleeve threaded joint (parallel thread) **(3)**	III	not allowed for: • pipes with outside diameter of more than 60,3 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.

(1) Welded butt-joints without special provisions for root side may be used for Classes II and III, any outside diameter.
(2) In particular cases, slip- on sleeve and socket welded joints may be allowed by the Society for piping systems of Class I and II having outside diameter <= 88,9 mm except for piping systems conveying toxic media or services where fatigue, severe erosion or crevice corrosion is expected to occur.
(3) In particular cases, sizes in excess of those mentioned above may be accepted by the Society if in compliance with a recognised national and/or international standard.

2.3.5 Mechanical joints

Due to the great variations in design and configuration of mechanical joints, no specific recommendation regarding the method for theoretical strength calculations is given in these requirements. The mechanical joints are to be type approved by the Society according to the "Rules for the type approval of mechanical joints for pipes".

These requirements are applicable to pipe unions, compression couplings and slip-on joints as shown in Fig 2. Similar joints complying with these requirements may be acceptable.

The application and pressure ratings of different mechanical joints are to be approved by the Society.

Mechanical joints including pipe unions, compression couplings, slip-on joints and similar joints are to be of approved type for the service conditions and the intended application.

Where the application of mechanical joints results in reduction in pipe wall thickness due to the use of bite type rings or other structural elements, this is to be taken into account in determining the minimum wall thickness of the pipe to withstand the design pressure.

Material of mechanical joints is to be compatible with the piping material and internal and external media.

Mechanical joints are to be tested where applicable, to a burst pressure of 4 times the design pressure.

For design pressures above 20 MPa the required burst pressure will be specially considered by the Society.

Where appropriate, mechanical joints are to be of fire-resistant type as required by Tab 16.

Mechanical joints which in the event of damage could cause fire or flooding are not to be used in piping sections directly connected to yacht's side below the freeboard deck or tanks containing flammable fluids.

The number of mechanical joints in flammable fluid systems is to be kept to a minimum. In general, flanged joints conforming to recognised standards are to be used.

Piping in which a mechanical joint is fitted is to be adequately adjusted, aligned and supported. Supports or hangers are not to be used to force alignment of piping at the point of connection.

Slip-on joints are not to be used in pipelines in spaces which are not easily accessible, except that these joints may be permitted in tanks that contain the same media.

Usage of slip type slip-on joints as the main means of pipe connection is not permitted except for cases where compensation of axial pipe deformation is necessary.

Application of mechanical joints and their acceptable use for each service are indicated in Tab 16; dependence upon the Class of piping and pipe dimensions are indicated in Tab 17.

In particular, Tab 16 indicates systems where the various kinds of joints may be accepted. However, in all cases, acceptance of the joint type is to be subject to approval of the intended application, and subject to conditions of the approval and applicable requirements. Further, relevant statutory requirements are to be taken into consideration. In cases exposure time (tT) is greater than 30 minutes the dry-wet test conditions are 8 minutes dry and, accordingly, the wet period tT-8 min.

In particular cases, sizes in excess of those mentioned above may be accepted if in compliance with a national and/or international standard recognised by the Society.

Mechanical joints are to be tested in accordance with a program approved by the Society, which is to include at least the following:

a) leakage test

b) vacuum test (where necessary)

c) vibration (fatigue) test

d) fire endurance test (where necessary)

e) burst pressure test

f) pressure pulsation test (where necessary)

g) assembly test (where necessary)

h) pull out test (where necessary).

The installation of mechanical joints is to be in accordance with the Manufacturer's assembly instructions. Where special tools and gauges are required for installation of the joints, these are to be supplied by the Manufacturer.

Figure 2 : Examples of mechanical joints

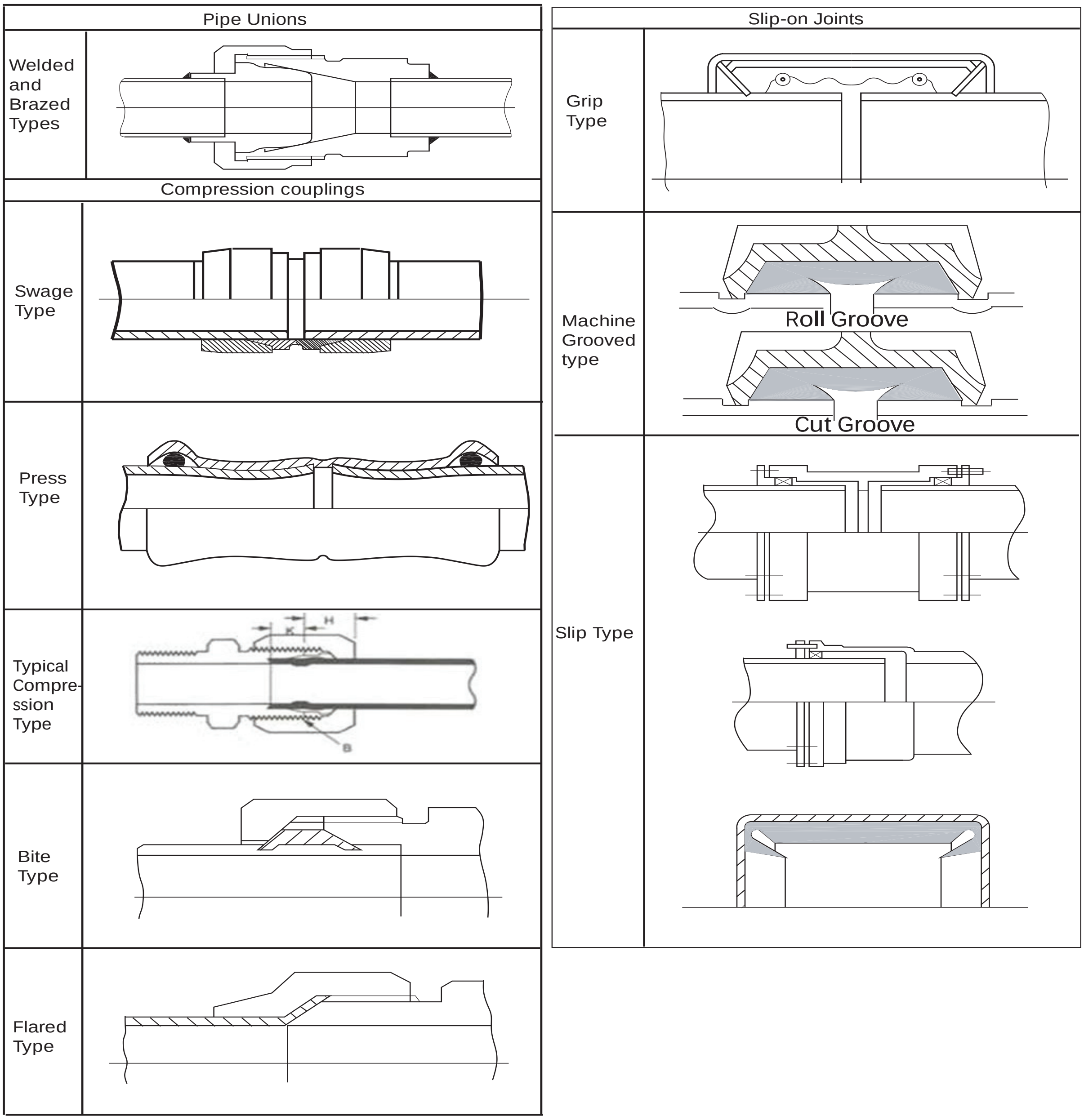


Table 16 : Application of mechanical joints *(1/1/2025)*

Systems		Kind of connections			Classification of pipe system	Fire endurance test condition7
		Pipe Unions	Compression Couplings	Slip-on Joints		
Flammable fluids (Flash point <= 60°)						
1	All lines **(1)**	+	+	+	dry	30 min dry (*)
2	Vent lines **(3)**	+	+	+	dry	
Flammable fluids (Flash point > 60°)						
3	Fuel oil lines **(2) (3)**	+	+	+	wet	30 min wet (*)
4	Lubricating oil lines **(2) (3)**	+	+	+	wet	30 min wet (*)
5	Hydraulic oil **(2) (3)**	+	+	+	wet	30 min wet (*)
Sea Water						
6	Bilge lines **(4)**	+	+	+	dry/wet	8 min dry + 22 min wet (*)
7	Permanent Water filled fire extinguishing systems, e.g. fire main, sprinkler systems **(3)**	+	+	+	wet	30 min wet (*)
8	Non-permanent water filled fire extinguishing systems, e.g. foam, drencher systems and fire main **(3)**	+	+	+	dry/wet	8 min dry + 22 min wet (*) For foam systems FSS Code Chapter 6 to be observed
9	Ballast system **(4)**	+	+	+	wet	30 min wet (*)
10	Cooling water system **(4)**	+	+	+	wet	30 min wet (*)
11	Tank cleaning services	+	+	+	dry	Fire endurance test not required
12	Non-essential systems	+	+	+	dry dry/wet wet	Fire endurance test not required
Fresh water						
13	Cooling water system **(4)**	+	+	+	wet	30 min wet (*)
14	Condensate return **(4)**	+	+	+	wet	30 min wet (*)
15	Non-essential system	+	+	+	dry dry/wet wet	Fire endurance test not required
Sanitary/Drains/Scuppers						

Abbreviations:

+ Application is allowed

- Application is not allowed

* Fire endurance test as specified in [5.5.6] of the Rules for the Type Approval of Mechanical Joints for Pipes

Footnotes - Table 16 - Fire resistance capability

If mechanical joints include any components which readily deteriorate in case of fire the following footnotes are to be observed:

(1) Fire endurance test is to be applied when mechanical joints are installed in open decks.

(2) Slip on joints are not accepted inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions (refer to MSC/Circ.734).

(3) Approved fire-resistant types except in cases where such mechanical joints are installed on open decks, and not used for fuel oil lines.

(4) Fire endurance test is to be applied when mechanical joints are installed inside machinery spaces of category A.

Footnotes - Table 16 - General

(5) Only above freeboard deck.

(6) Slip type slip-on joints as shown in Table 16. May be used for pipes on deck with a design pressure of 10 bar or less.

(7) If a connection has passed the "30 min dry" test, it is considered suitable also for applications for which the "8 min dry+22 min wet" and/or "30 min wet " tests are required. If a connection has passed the "8 min dry+22 min wet" test, it is considered suitable also for applications for which the "30 min wet" test is required.

Systems		Kind of connections			Classification of pipe system	Fire endurance test condition7
		Pipe Unions	Compression Couplings	Slip-on Joints		
16	Deck drains (internal) **(5)**	+	+	+	dry	Fire endurance test not required
17	Sanitary drains	+	+	+	dry	
18	Scuppers and discharge (overboard)	+	+	-	dry	
Sounding/Vent						
19	Water tanks/Dry spaces	+	+	+	dry, wet	Fire endurance test not required
20	Oil tanks (f.p.> 60°C) **(2) (3)**	+	+	+	dry	
Miscellaneous						
21	Starting/Control air **(4)**	+	+	-	dry	30 min dry (*)
22	Service air (non-essential)	+	+	+	dry	Fire endurance test not required
23	Brine	+	+	+	wet	
24	CO_2 system (outside protected space)	+	+	-	dry	30 min dry (*)
25	CO_2 system (inside protected space)	+	+	-	dry	Mechanical joints are to be constructed of materials with melting point above 925°C. Ref. to FSS Code Chapter 5.
	Urea	+	+	+	wet	30 min (*)

Abbreviations:
+ Application is allowed
- Application is not allowed
* Fire endurance test as specified in [5.5.6] of the Rules for the Type Approval of Mechanical Joints for Pipes

Footnotes - Table 16 - Fire resistance capability

If mechanical joints include any components which readily deteriorate in case of fire the following footnotes are to be observed:

(1) Fire endurance test is to be applied when mechanical joints are installed in open decks.

(2) Slip on joints are not accepted inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions (refer to MSC/Circ.734).

(3) Approved fire-resistant types except in cases where such mechanical joints are installed on open decks, and not used for fuel oil lines.

(4) Fire endurance test is to be applied when mechanical joints are installed inside machinery spaces of category A.

Footnotes - Table 16 - General

(5) Only above freeboard deck.

(6) Slip type slip-on joints as shown in Table 16. May be used for pipes on deck with a design pressure of 10 bar or less.

(7) If a connection has passed the "30 min dry" test, it is considered suitable also for applications for which the "8 min dry+22 min wet" and/or "30 min wet " tests are required. If a connection has passed the "8 min dry+22 min wet" test, it is considered suitable also for applications for which the "30 min wet" test is required.

Table 17 : Application of mechanical joints depending upon the class of piping

Types of joints	Classes of piping systems		
	Class I	Class II	Class III
Pipe Unions			
Welded and brazed type	yes (outside diameter <= 60.3mm)	yes (outside diameter £ 60.3mm)	yes
Compression Couplings			
Swage type	yes	yes	yes
yes means application is allowed not means application is not allowed			

Types of joints	Classes of piping systems		
Bite type Typical compression type Flared type	yes (outside diameter <= 60.3mm) yes (outside diameter <= 60.3mm) yes (outside diameter <= 60.3mm)	yes (outside diameter <= 60.3mm) yes (outside diameter <= 60.3mm) yes (outside diameter <= 60.3mm)	yes yes yes
Press type	not	not	yes
Slip-on joints			
Machine grooved type	yes	yes	yes
Grip type	not	yes	yes
Slip type	not	yes	yes
yes means application is allowed not means application is not allowed			

2.4 Protection against overpressure

2.4.1 General

a) These requirements deal with the protection of piping systems against overpressure, with the exception of heat exchangers and pressure vessels, which are dealt with in Sec 3, [2.4].

b) Safety valves are to be sealed after setting.

2.4.2 Protection of flammable oil systems

Provisions shall be made to prevent overpressure in any flammable oil tank or in any part of the flammable oil systems, including the filling pipes served by pumps on board.

2.4.3 Protection of pump and compressor discharges

a) Provisions are to be made so that the discharge pressure of pumps and compressors cannot exceed the pressure for which the pipes located on the discharge of these pumps and compressors are designed.

b) When provided on the pump discharge for this purpose, safety valves are to lead back to the pump suction or to any other suitable place.

c) The discharge capacity of the safety valves installed on pumps and compressors is to be such that the pressure at the discharge side cannot exceed by more than 10% the design pressure of the discharge pipe in the event of operation with closed discharge.

2.4.4 Protection of pipes

a) Pipes likely to be subjected to a pressure exceeding their normal working pressure are to be provided with safety valves or equivalent overpressure protecting devices.

b) In particular, pipes located on the low pressure side of pressure reducing valves are to be provided with safety valves unless they are designed for the maximum pressure on the high pressure side of the pressure reducing valve. See also [1.3.2] and [2.8.1].

c) The discharge capacity of the devices fitted on pipes for preventing overpressure is to be such that the pressure in these pipes cannot exceed the design pressure by more than 10%.

2.5 Flexible hoses and expansion joints

2.5.1 General (1/7/2022)

a) The Society may permit the use of flexible hose assemblies (short lengths of hose normally with prefabricated end fittings ready for installation), for permanent connection between a fixed piping system and items of machinery, and expansion joints, both in metallic and non-metallic materials, provided they are approved for the intended service.

Note 1: Flexible hose assemblies for essential services or containing either flammable or toxic media are not to exceed 1,5 m in length.

b) Flexible hoses and expansion joints are to be of a type approved by the Society, designed in accordance with [2.6.2] and tested in accordance with [17.2.1].

c) These requirements may also be applied to temporary connected flexible hoses or hoses of portable equipment, and media not indicated in d).

d) Flexible hose assemblies as defined in a) may be accepted for use in fuel oil, lubricating, hydraulic and thermal oil systems, fresh water and sea water cooling systems, compressed air systems, bilge and ballast systems, and Class III steam systems. Flexible hoses in high pressure fuel oil injection systems are not accepted.

e) Flexible hoses and expansion joints are to be installed in accordance with the requirements stated in [5.9.3].

f) These requirements for flexible hose assemblies are not applicable to hoses intended to be used in fixed fire-extinguishing systems.

g) Flexible hoses and expansion joints intended for piping systems with a design temperature below the ambient temperature will be given special consideration by the Society.

h) The position of flexible hoses and expansion joints is to be clearly shown on the piping drawings submitted to the Society.

2.5.2 Design of flexible hoses and expansion joints

a) Flexible hoses and expansion joints are to be made of materials resistant to the marine environment and to the fluid they are to convey. Metallic materials are to comply with [2.1].

b) Flexible hoses are to be designed and constructed in accordance with recognised national or international standards acceptable to the Society.

c) Flexible hoses constructed of rubber materials and intended for use in bilge, ballast, compressed air, fuel oil, lubricating and hydraulic oil systems are to incorporate a single, double or more closely woven integral wire braid or other suitable material reinforcement.

   Flexible hoses of plastics materials for the same purposes, such as Teflon or nylon, which are unable to be reinforced by incorporating closely woven integral wire braid are to have suitable material reinforcement as far as practicable.

d) Where rubber or plastic material hoses are to be used in oil supply lines to burners, the hoses are to have external wire braid protection in addition to the reinforcement mentioned above.

e) Flexible hoses are to be complete with approved end fittings in accordance with the Manufacturer's specification. End connections that do not have a flange are to comply with [2.3.5] as applicable and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose with particular reference to pressure and impulse tests.

f) The use of hose clamps and similar types of end attachments is not acceptable for flexible hoses in piping systems for steam, flammable media, starting air systems or for sea water systems where failure may result in flooding. In other piping systems, the use of hose clamps may be accepted where the working pressure is less than 0,5 MPa and provided there are double clamps at each end connection.

g) Flexible hoses and expansion joints are to be so designed as to withstand the bursting pressure requested by the "Rules for the type approval of flexible hoses and expansion joints".

h) Flexible hose assemblies and expansion joints intended for installation in piping systems where pressure pulses and/or high levels of vibration are expected to occur in service are to be designed for the maximum expected impulse peak pressure and forces due to vibration. The tests required in [17.2.1] are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to installation.

i) Flexible hose assemblies and expansion joints constructed of non-metallic materials intended for installation in piping systems for flammable media and sea water systems where failure may result in flooding are to be of fire-resistant type, except in cases where such hoses are installed on open decks and not used for fuel oil lines. Fire resistance is to be demonstrated by testing according to ISO 15540:2016 and 15541:2016.

j) Flexible hose assemblies are to be selected for the intended location and application taking into consideration ambient conditions, compatibility with fluids under working pressure and temperature conditions consistent with the Manufacturer's instructions.

2.5.3 Conditions of use of expansion joints in sea water systems and within duct keels and tanks

a) The use of non-metallic expansion joints on pipes connected to sea inlets and overboard discharges will be given special consideration by the Society. As a rule, the fitting of such joints between the side and the valves mentioned in [2.7.3] is not permitted. Furthermore, unless the above-mentioned valves are fitted with remote controls operable from places located above the freeboard deck, the expansion joints are to be arranged with guards which effectively enclose, but do not interfere with, the action of the expansion joints and reduce to the minimum practicable any flow of water into the machinery spaces in the event of failure of the flexible elements.

b) Use of expansion joints in water lines for other services, including ballast lines in machinery spaces, in duct keels and inside double bottom water ballast tanks, and bilge lines inside double bottom tanks and deep tanks, will be given special consideration by the Society.

2.6 Valves and accessories

2.6.1 General

a) Valves and accessories are normally to be built in accordance with a recognised standard.

Valves and fittings in piping systems are to be compatible with the pipes to which they are attached in respect of their strength (see [1.3.2] for design pressure) and are to be suitable for effective operation at the maximum working pressure they will experience in service.

Failing this, they are to be approved by the Society when they are fitted:

- in a class I piping system, or
- in a class II piping system with a diameter exceeding 100 mm, or
- on the yacht side, on the collision bulkhead or on fuel tanks under static pressure.

b) Shut-off valves are to be provided where necessary to isolate pumps, heat exchangers, pressure vessels, etc., from the rest of the piping system when necessary, and in particular:

- to allow the isolation of duplicate components without interrupting the fluid circulation
- for survey or repair purposes.

2.6.2 Design of valves and accessories

a) Materials of valve and accessory bodies are to comply with the provisions of [2.1].

b) Connections of valves and accessories with pipes are to comply with the provisions of [2.3].

c) All valves and accessories are to be so designed as to prevent the loosening of covers and glands when they are operated.

d) Valves are to be so designed as to shut with a right-hand (clockwise) motion of the wheels.

e) Valves are to be provided with local indicators showing whether they are open or shut, unless this is readily apparent.

2.6.3 Valves with remote control

a) All valves which are provided with remote control are also to be designed for local manual operation.

b) The remote control system and means of local operation are to be independent. In this respect, arrangement of the local operation by means of a fixed hand pump will be specially considered by the Society.

c) In the case of valves which are to be provided with remote control in accordance with the Rules, opening and/or closing of the valves by local manual means is not to render the remote control system inoperable.

d) Power failure of the remote control system is not to cause an undesired change of the valve position.

2.7 Sea inlets and overboard discharges

2.7.1 General

Except where expressly stated in Article [8], the requirements of this sub-article do not apply to scuppers and sanitary discharges.

2.7.2 Design of sea inlets and overboard discharges

a) All inlets and discharges in the shell plating are to be fitted with efficient and accessible arrangements for preventing the accidental admission of water into the yacht.

b) Sea inlets and overboard discharges are to be fitted with valves complying with [2.6] and [2.7.3].

c) Machinery space main and auxiliary sea inlets and discharges in connection with the operation of machinery are to be fitted with readily accessible valves between the pipes and the shell plating or between the pipes and fabricated boxes attached to the shell plating. The valves may be controlled locally and are to be provided with indicators showing whether they are open or closed.

d) Sea inlets are to be so designed and arranged as to limit turbulence and to avoid the admission of air due to motion of the yacht .

e) Sea inlets are to be fitted with gratings complying with [2.7.4].

f) Provisions are to be made for clearing sea inlet gratings, where necessary.

g) Sea chests are to be suitably protected against corrosion.

2.7.3 Valves

a) Sea inlet and overboard discharge valves are to be secured:
   - directly on the shell plating, or
   - on sea chests built on the shell plating, with scantlings in compliance with Part B, or
   - on extra-reinforced and short distance pieces attached to the shell (see Tab 5).

b) The bodies of the valves and distance pieces are to have a spigot passing through the plating without projecting beyond the external surface of such plating or of the doubling plates and stiffening rings, if any.

c) Valves are to be secured by means of:
   - bolts screwed through the plating with a countersunk head, or
   - studs screwed in heavy pads themselves secured to the hull or chest plating, without penetration of the plating by the stud holes.

d) The use of butterfly valves will be specially considered by the Society. In any event, butterfly valves not fitted with flanges are not to be used for water inlets or overboard discharges unless provisions are made to allow disassembling at sea of the pipes served by these valves without any risk of flooding.

e) The materials of the valve bodies and connecting pieces are to comply with [2.1.2] and Tab 4.

f) side valves serving piping systems made of plastics are to comply with App 3, [3.7.1].

2.7.4 Gratings

a) Gratings are to have a free flow area not less than twice the total section of the pipes connected to the inlet.

b) When gratings are secured by means of screws with a countersunk head, the tapped holes provided for such screws are not to pass through the plating or doubling plates outside distance pieces or chests.

c) Screws used for fixing gratings are not to be located in the corners of openings in the hull or of doubling plates.

d) In the case of large sea inlets, the screws used for fixing the gratings are to be locked and protected from corrosion.

e) When gratings are cleared by use of compressed air or steam devices, the chests, distance pieces and valves of sea inlets and outlets thus arranged are to be so constructed as to withstand the maximum pressure to which they may be subjected when such devices are operating.

2.8 Control and monitoring

2.8.1 General

a) Local indicators are to be provided for at least the following parameters:
   - pressure, in pressure vessels, at pump or compressor discharge, at the inlet of the equipment served, on the low pressure side of pressure reducing valves
   - temperatures, in tanks and vessels, at heat exchanger inlet and outlet
   - levels, in tanks and vessels containing liquids.

b) Safeguards are to be provided where an automatic action is necessary to restore acceptable values for a faulty parameter.

c) Automatic controls are to be provided where it is necessary to maintain parameters related to piping systems at a pre-set value.

2.8.2 Level gauges

Level gauges used in fuel oil systems, pressure lubricating oil systems and other flammable oil systems are to be of a type approved by the Society and are subject to the following condition:

- their failure or overfilling of the tank is not to permit release of fuel into the space. The use of cylindrical gauges is prohibited. The Society may permit the use of oil-level gauges with flat glasses and self-closing valves between the gauges and fuel tanks. Their glasses are to be made of heat-resistant material and efficiently protected against shocks.

The above level gauges are to be maintained in the proper condition to ensure their continued accurate functioning in service.

3 Welding of steel piping

3.1 Application

3.1.1

a) The following requirements apply to welded joints belonging to class I or II piping systems.
They may also be applied to class III piping systems, at the discretion of the Society.

b) The requirements for qualification of welding procedures are given in Part D.

3.2 General

3.2.1 Welding processes

a) Welded joints of pipes are to be made by means of electric arc or oxyacetylene welding, or any other previously approved process.

b) When the design pressure exceeds 0,7 MPa, oxyacetylene welding is not permitted for pipes with an external diameter greater than 100 mm or a thickness exceeding 6 mm.

3.2.2 Location of joints

The location of welded joints is to be such that as many as possible can be made in a workshop. The location of welded joints to be made on board is to be so determined as to permit their joining and inspection in satisfactory conditions.

3.3 Design of welded joints

3.3.1 Types of joints

a) Except for the fixing of flanges on pipes in the cases mentioned in [2.3.4], Fig 1 and for the fixing of branch pipes, joints between pipes and between pipes and fittings are to be of the butt-welded type. However, for class I pipes with an internal diameter not exceeding 50 mm and for class II pipes, socket welded connections of approved types may be used.

b) For butt-welded joints between pipes or between pipes and flanges or other fittings, correctly adjusted backing rings may be used; such rings are to be either of the same grade of steel as the elements to be welded or of such a grade as not to adversely influence the weld; if the backing ring cannot be removed after welding, it is to be correctly profiled.

3.3.2 Assembly of pipes of unequal thickness

If the difference of thickness between pipes to be butt-welded exceeds 10% of the thickness of the thinner pipe plus 1 mm, subject to a maximum of 4 mm, the thicker pipe is to be thinned down to the thickness of the thinner pipe on a length at least equal to 4 times the offset, including the width of the weld if so desired.

3.3.3 Accessories

a) When accessories such as valves are connected by welding to pipes, they are to be provided with necks of sufficient length to prevent abnormal deformations during the execution of welding or heat treatment.

b) For the fixing by welding of branch pipes on pipes, it is necessary to provide either a thickness increase as indicated in [2.2.5] or a reinforcement by doubling plate or equivalent.

3.4 Preparation of elements to be welded and execution of welding

3.4.1 General

Attention is drawn to the provisions of Sec 3, which apply to the welding of pressure pipes.

3.4.2 Edge preparation for welded joints

The preparation of the edges is preferably to be carried out by mechanical means. When flame cutting is used, care is to be taken to remove the oxide scales and any notch due to irregular cutting by matching, grinding or chipping back to sound metal.

3.4.3 Abutting of parts to be welded

a) The elements to be welded are to be so abutted that surface misalignments are as small as possible.

b) As a general rule, for elements which are butt-welded without a backing ring the misalignment between internal walls is not to exceed the lesser of:

- the value given in Tab 18 as a function of thickness t and internal diameter d of these elements, and

- t/4.

Where necessary, the pipe ends are to be bored or slightly expanded so as to comply with these values; the thickness obtained is not to be less than the Rule thickness.

c) In the case of welding with a backing ring, smaller values of misalignment are to be obtained so that the space between the backing ring and the internal walls of the two elements to be assembled is as small as possible; normally this space is not to exceed 0,5 mm.

d) The elements to be welded are to be adequately secured so as to prevent modifications of their relative position and deformations during welding.

e) Tack welds should be made with an electrode suitable for the base metal; tack welds which form part of the finished weld should be made using approved procedures.

When welding materials requiring preheating are employed, the same preheating should be applied during tack welding.

Table 18 : Maximum value of misalignment

d (mm)	t (mm)		
	$t \leq 6$	$6 < t \leq 10$	$10 < t$
d < 150	1,0	1,0	1,0
150 ≤ d < 300	1,0	1,5	1,5
d > 300	1,0	1,5	2,0

3.4.4 Protection against adverse weather conditions

a) Pressure pipes are to be welded, both on board and in the shop, away from draughts and sudden temperature variations.

b) Unless special justification is given, no welding is to be performed if the temperature of the base metal is lower than 0°C.

3.4.5 Preheating

a) Preheating is to be performed as indicated in Tab 19, depending on the type of steel, the chemical composition and the pipe thickness.

b) The temperatures given in Tab 19 are based on the use of low hydrogen processes. Where low hydrogen processes are not used, the Society reserves the right to require higher preheating temperatures.

Table 19 : Preheating temperature

Type of steel		Thickness of thicker part (mm)	Minimum preheating temperature (°C)
C and C-Mn steels	$C + \frac{Mn}{6} \leq 0,40$	$t \geq 20$ **(2)**	50
	$C + \frac{Mn}{6} > 0,40$	$t \geq 20$ **(2)**	100
0,3 Mo		$t \geq 13$ **(2)**	100
1 Cr 0,5 Mo		$t < 13$ $t \geq 13$	100 150
2,25 Cr 1 Mo **(1)**		$t < 13$ $t \geq 13$	150 200
0,5 Cr 0,5 Mo 0,25 V **(1)**		$t < 13$ $t \geq 13$	150 200

(1) For 2,25 Cr 1 Mo and 0,5 Cr 0,5 Mo 0,25 V grades with thicknesses up to 6 mm, preheating may be omitted if the results of hardness tests carried out on welding procedure qualification are considered acceptable by the Society.
(2) For welding in ambient temperature below 0°C, the minimum preheating temperature is required independent of the thickness unless specially approved by the Society.

3.5 Post-weld heat treatment

3.5.1 General

a) As far as practicable, the heat treatment is to be carried out in a furnace. Where this is impracticable, and more particularly in the case of welding on board, the treatment is to be performed locally by heating uniformly a circular strip, extending on at least 75 mm on both sides of the welded joint; all precautions are to be taken to permit accurate checking of the temperature and slow cooling after treatment.

b) For austenitic and austenitic ferritic steels, post-weld head treatment is generally not required.

3.5.2 Heat treatment after welding other than oxyacetylene welding

a) Stress relieving heat treatment after welding other than oxyacetylene welding is to be performed as indicated in Tab 20, depending on the type of steel and thickness of the pipes.

b) The stress relieving heat treatment is to consist in heating slowly and uniformly to a temperature within the range indicated in the Table, soaking at this temperature for a suitable period, normally one hour per 25 mm of thickness with a minimum of half an hour, cooling slowly and uniformly in the furnace to a temperature not exceeding 400°C and subsequently cooling in still atmosphere.

c) In any event, the heat treatment temperature is not to be higher than (T_T - 20)°C, where T_T is the temperature of the final tempering treatment of the material

Table 20 : Heat treatment temperature

Type of steel	Thickness of thicker part (mm)	Stress relief treatment temperature (°C)
C and C-Mn steels	t ≥ 15 **(1)** **(3)**	550 to 620
0,3 Mo	t ≥ 15 **(1)**	580 to 640
1 Cr 0,5 Mo	t ≥ 8	620 to 680
2,25 Cr 1 Mo 0,5 Cr 0,5 Mo 0,25 V	any **(2)**	650 to 720

(1) Where steels with specified Charpy V notch impact properties at low temperature are used, the thickness above which post-weld heat treatment is to be applied may be increased, subject to the special agreement of the Society.

(2) For 2,25Cr 1Mo and 0,5Cr 0,5Mo 0,25 V grade steels, heat treatment may be omitted for pipes having thickness lower than 8 mm, diameter not exceeding 100 mm and service temperature not exceeding 450°C.

(3) For C and C-Mn steels, stress relieving heat treatment may be omitted up to 30 mm thickness, subject to the special agreement of the Society.

3.5.3 Heat treatment after oxyacetylene welding

Stress relieving heat treatment after oxyacetylene welding is to be performed as indicated in Tab 21, depending on the type of steel.

Table 21 : Heat treatment after oxyacetylene welding

Type of steel	Heat treatment and temperature (°C)
C and C-Mn	Normalising 880 to 940
0,3 Mo	Normalising 900 to 940
1Cr-0,5Mo	Normalising 900 to 960 Tempering 640 to 720
2,25Cr-1Mo	Normalising 900 to 960 Tempering 650 to 780
0,5Cr-0,5Mo-0,25V	Normalising 930 to 980 Tempering 670 to 720

3.6 Inspection of welded joints

3.6.1 General

a) The inspection of pressure pipe welded joints is to be performed at the various stages of the fabrication further to the qualifications defined in [3.1.1], item c).

b) The examination mainly concerns those parts to be welded further to their preparation, the welded joints once they have been made and the conditions for carrying out possible heat treatments.

c) The required examinations are to be carried out by qualified operators in accordance with procedures and techniques to the Surveyor's satisfaction.

3.6.2 Visual examination

Welded joints, including the inside wherever possible, are to be visually examined.

3.6.3 Non-destructive examinations

a) Non-destructive tests for class I pipes are to be performed as follows:
   - butt-welded joints of pipes with an external diameter exceeding 75 mm are to be subjected to full radiographic examination or equivalent
   - welded joints other than butt-welded joints and which cannot be radiographed are to be examined by magnetic particle or liquid penetrant tests
   - fillet welds of flange connections are to be examined by magnetic particle tests or by other appropriate non-destructive tests.

b) Non-destructive tests for class II pipes are to be performed as follows:
   - butt-welded joints of pipes with an external diameter exceeding 100 mm are to be subjected to at least 10% random radiographic examination or equivalent
   - welded joints other than butt-welded joints are to be examined by magnetic particle tests or by other appropriate non-destructive tests
   - fillet welds of flange connections may be required to be examined by magnetic particle tests or by other appropriate non-destructive tests, at the discretion of the Surveyor.

3.6.4 Defects and acceptance criteria

a) Joints for which non-destructive examinations reveal unacceptable defects are to be re-welded and subsequently to undergo a new non-destructive examination. The Surveyor may require that the number of joints to be subjected to non-destructive examination is larger than that resulting from the provisions of [3.6.3].

b) The acceptance criteria of defects are:
   - for class I pipes, those defined in the "Rules for carrying out not-destructive examinations of welding" for the special quality level,
   - for class II pipes, those defined in the "Rules for carrying out not-destructive examinations of welding" for the normal quality level.

4 Bending of pipes

4.1 Application

4.1.1 This Article applies to pipes made of:

- alloy or non-alloy steels,
- copper and copper alloys.

4.2 Bending process

4.2.1 General

The bending process is to be such as not to have a detrimental influence on the characteristics of the materials or on the strength of the pipes.

4.2.2 Bending radius

The bending radius measured on the centreline of the pipe is not to be less than:

- twice the external diameter for copper and copper alloy pipes,
- 3 times the external diameter for cold bent steel pipes.

Smaller bending radius may be accepted for specific applications (pipe materials and geometries), based on the results of relevant studies that demonstrate that the strength characteristics of the pipe is not negatively affected by the bending.

4.2.3 Acceptance criteria

a) The pipes are to be bent in such a way that, in each transverse section, the difference between the maximum and minimum diameters after bending does not exceed 10% of the mean diameter; higher values, but not exceeding 15%, may be allowed in the case of pipes which are not subjected in service to appreciable bending stresses due to thermal expansion or contraction.

b) The bending is to be such that the depth of the corrugations is as small as possible and does not exceed 5% of their length.

4.2.4 Hot bending

a) In the case of hot bending, all arrangements are to be made to permit careful checking of the metal temperature and to prevent rapid cooling, especially for alloy steels.

b) Hot bending is to be generally carried out in the temperature range 850°C-1000°C for all steel grades; however, a decreased temperature down to 750°C may be accepted during the forming process.

4.3 Heat treatment after bending

4.3.1 Copper and copper alloy

Copper and copper alloy pipes are to be suitably annealed after cold bending if their external diameter exceeds 50 mm.

4.3.2 Steel

a) After hot bending carried out within the temperature range specified in [4.2.4], the following applies:
   - for C, C-Mn and C-Mo steels, no subsequent heat treatment is required,
   - for Cr-Mo and Cr-Mo-V steels, a subsequent stress relieving heat treatment in accordance with Tab 20 is required.

b) After hot bending performed outside the temperature range specified in [4.2.4], a subsequent new heat treatment in accordance with Tab 21 is required for all grades.

c) After cold bending at a radius lower than 4 times the external diameter of the pipe, a heat treatment in accordance with Tab 21 is required.

5 Arrangement and installation of piping systems

5.1 General

5.1.1 Unless otherwise specified, piping and pumping systems covered by the Rules are to be permanently fixed on board .

5.2 Location of tanks and piping system components

5.2.1 Flammable oil systems

Location of tanks and piping system components conveying flammable fluids under pressure is to comply with [5.10].

5.2.2 Piping systems with open ends

Attention is to be paid to the requirements for the location of open-ended pipes on board s having to comply with the provisions of [5.5].

5.2.3 Pipe lines located inside tanks

a) The passage of pipes through tanks, when permitted, requires special arrangements such as reinforced thickness as per Tab 5 for steel pipes or tunnels, in particular for:
   - bilge pipes
   - ballast pipes
   - scuppers and sanitary discharges
   - air, sounding and overflow pipes
   - fuel oil pipes.

b) Junctions of pipes inside tanks are to be made by welding or welded reinforced flange connections. See also [2.4.3].

5.2.4 Overboard discharges

Overboard discharges are to be so located as to prevent any discharge of water into the lifeboats while they are being lowered.

5.2.5 Piping and electrical apparatus

The installation of piping near switchboards and other electrical apparatus is to comply with Ch 2, Sec 12, [6.1.7].

5.3 Passage through watertight bulkheads or decks

5.3.1 Penetration of watertight bulkheads and decks

a) Where penetrations of watertight bulkheads and internal decks are necessary for piping and ventilation, arrangements are to be made to maintain the watertight integrity.

b) Lead or other heat sensitive materials are not to be used in piping systems which penetrate watertight subdivision bulkheads or decks, where deterioration of such systems in the event of fire would impair the watertight integrity of the bulkhead or decks.

   This applies in particular to the following systems:

   - bilge system
   - ballast system
   - scuppers and sanitary discharge systems.

c) Where bolted connections are used for piping passing through watertight bulkheads or decks, the bolts are to be screwed in heavy pads secured to the bulkhead or deck plating without penetration of the plating by the bolt holes. Where welded connections are used, they are to be welded on both sides of the bulkhead or deck plating.

d) Penetrations of watertight bulkheads or decks by plastic pipes are to comply with App 3, [3.6.2].

5.3.2 Passage through the collision bulkhead

See Pt B, Ch 1, Sec 1, [5.1.3].

5.4 Independence of lines

5.4.1 As a general rule, bilge and ballast lines are to be entirely independent and distinct from lines conveying lubricating oil and fuel oil, with the exception of:

- pipes located between collecting boxes and pump suctions
- pipes located between pumps and overboard discharges
- pipes supplying compartments likely to be used alternatively for ballast or fuel oil, provided such pipes are fitted with blind flanges or other appropriate change-over devices, in order to avoid any mishandling.

5.5 Prevention of progressive flooding

5.5.1 Principle

a) In order to comply with the subdivision and damage stability requirements, when required, provision is to be made to prevent any progressive flooding of a dry compartment served by any open-ended pipe, in the event that such pipe is damaged or broken in any other compartment by collision or grounding.

b) For this purpose, if pipes are situated within assumed flooded compartments, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage. However, the Society may permit minor progressive flooding if it is demonstrated that its effects can be easily controlled and the safety of the is not impaired.

5.5.2 Extent of damage

For the definition of the assumed transverse extent of damage, see the relevant stability requirements.

5.5.3 Piping arrangement

a) The assumed transverse extent of damage is not to contain any pipe with an open end in a compartment located outside this extent.

b) Where the provisions of a) cannot be fulfilled, and after special examination by the Society, pipes may be situated within the assumed transverse extent of damage penetration provided that:

   - either a closable valve operable from above the bulkhead deck is fitted at each penetration of a watertight subdivision and secured directly on the bulkhead, or
   - a closable valve operable from above the bulkhead deck is fitted at each end of the pipe concerned, the valves and their control system being inboard of the assumed extent of damage, or
   - the tanks to which the pipe concerned leads are regarded in the damage stability calculations as being flooded when damage occurs in a compartment through which the pipe passes.

c) Valves required to be operable from above the bulkhead deck are to be fitted with an indicator to show whether the valve is open or shut.

Where the valve is remote controlled by other than mechanical means, and where the remote control system is located, even partly, within the assumed extent of damage penetration, this system is to be such that the valve is automatically closed by loss of power.

d) Air and overflow pipes are to be so arranged as to prevent the possibility of flooding of other tanks in other watertight compartments in the event of any one tank being flooded.

This arrangement is to be such that in the range of positive residual righting levers beyond the angle of equilibrium stage of flooding, the progressive flooding of tanks or watertight compartments other than that flooded does not occur.

5.6 Provision for expansion

5.6.1 General

Piping systems are to be so designed and pipes so fixed as to allow for relative movement between pipes and the yacht's structure, having due regard to:

- the temperature of the fluid conveyed
- the coefficient of thermal expansion of the pipes material
- the deformation of the yachts's hull.

5.6.2 Fitting of expansion devices

All pipes subject to thermal expansion and those which, due to their length, may be affected by deformation of the hull, are to be fitted with expansion pieces or loops.

5.7 Supporting of the pipes

5.7.1 General

Unless otherwise specified, the fluid lines referred to in this Section are to consist of pipes connected to the 's structure by means of collars or similar devices.

5.7.2 Arrangement of supports

Shipyards are to take care that:

a) The arrangement of supports and collars is to be such that pipes and flanges are not subjected to abnormal bending stresses, taking into account their own mass, the metal they are made of, and the nature and characteristics of the fluid they convey, as well as the contractions and expansions to which they are subjected.

b) Heavy components in the piping system, such as valves, are to be independently supported.

5.8 Protection of pipes

5.8.1 Protection against corrosion and erosion

a) Pipes are to be efficiently protected against corrosion, particularly in their most exposed parts, either by selection of their constituent materials, or by an appropriate coating or treatment.

b) The layout and arrangement of sea water pipes are to be such as to prevent sharp bends and abrupt changes in section as well as zones where water may stagnate. The inner surface of pipes is to be as smooth as possible, especially in way of joints. Where pipes are protected against corrosion by means of galvanising or other inner coating, arrangements are to be made so that this coating is continuous, as far as possible, in particular in way of joints.

c) If galvanised steel pipes are used for sea water systems, the water velocity is not to exceed 3 m/s.

d) If copper pipes are used for sea water systems, the water velocity is not to exceed 2 m/s.

e) Arrangements are to be made to avoid galvanic corrosion.

5.8.2 Protection against frosting

Pipes are to be adequately insulated against cold wherever deemed necessary to prevent frost.

This applies specifically to pipes passing through refrigerated spaces and which are not intended to ensure the refrigeration of such spaces.

5.8.3 Protection of high temperature pipes and components

a) All pipes and other components where the temperature may exceed 220°C are to be efficiently insulated, as indicated in Sec 1, [3.7].

b) Particular attention is to be paid to lagging in way of flanges.

5.9 Valves, accessories and fittings

5.9.1 General

Cocks, valves and other accessories are generally to be arranged so that they are easily visible and accessible for manoeuvring, control and maintenance. They are to be installed in such a way as to operate properly.

5.9.2 Valves and accessories

a) In machinery spaces and tunnels, the cocks, valves and other accessories of the fluid lines referred to in this Section are to be placed:
   - above the floor,
   - or, when this is not possible, immediately under the floor, provided provision is made for their easy access and control in service.

b) Control-wheels of low inlet valves are to rise at least 0,45 m above the lowest floor.

5.9.3 Flexible hoses and expansion joints

a) Flexible hoses are to be so arranged as to be clearly visible and readily accessible at all times.

b) In general, flexible hoses and expansion joints are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery/equipment or systems.

c) Flexible hose assemblies and expansion joints are not to be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions.

d) The adjoining pipes are to be suitably aligned, supported, guided and anchored.

e) The number of flexible hoses and expansion joints is to be kept to a minimum.

f) Where flexible hoses and expansion joints are intended to be used in piping systems conveying flammable fluids that are in close proximity to heated surfaces, the risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated as far as practicable by the use of screens or other similar protection to the satisfaction of the Society.

g) Expansion joints are to be protected against over-extension and over-compression.

h) The installation of flexible hose assemblies and expansion joints is to be in accordance with the Manufacturer's instructions and use limitations with particular attention to the following, as applicable:
   - orientation
   - end connection support (where necessary)
   - avoidance of hose contact that could cause rubbing and abrasion
   - minimum bend radii.

5.9.4 Thermometers

Thermometers and other temperature-detecting elements in fluid systems under pressure are to be provided with pockets built and secured so that the thermometers and detecting elements can be removed while keeping the piping under pressure.

5.9.5 Pressure gauges

Pressure gauges and other similar instruments are to be fitted with an isolating valve or cock at the connection with the main pipe.

5.9.6 Nameplates

a) Accessories such as cocks and valves on the fluid lines referred to in this Section are to be provided with nameplates indicating the apparatus and lines they serve except where, due to their location on board, there is no doubt as to their purpose.

b) Nameplates are to be fitted at the upper part of air and sounding pipes.

5.10 Additional arrangements for flammable fluids

5.10.1 General

The requirements in [5.10.3] and [5.10.4] apply to:

- fuel oil systems, in all spaces
- lubricating oil systems, in machinery spaces
- other flammable oil systems, in locations where means of ignition are present.

5.10.2 Prohibition of carriage of flammable oils in forepeak tanks *(1/1/2025)*

Fuel oil, lubricating oil and other flammable oils are not to be carried in forepeak tanks or tanks forward of the collision bulkhead.

5.10.3 Prevention of flammable oil leakage ignition *(1/1/2025)*

a) As far as practicable, parts of the fuel oil and lubricating oil systems containing heated oil under pressure exceeding 0,18 MPa are to be placed above the platform or in any other position where defects and leakage can readily be observed.

The machinery spaces in way of such parts are to be adequately illuminated.

b) No flammable oil tanks are to be situated where spillage or leakage therefrom can constitute a hazard by falling on:
   - hot surfaces, including those of heaters, exhaust manifolds and silencers
   - electrical equipment
   - air intakes
   - other sources of ignition.

c) Parts of flammable oil systems under pressure exceeding 0,18 MPa such as pumps, filters and heaters are to comply with the provisions of b) above.

d) Flammable oil lines are not to be located immediately above or near units of high temperature including exhaust manifolds, silencers or other equipment required to be insulated in Sec 1, [3.7.1]. As far as practicable, flammable oil lines are to be arranged far from hot surfaces, electrical installations or other sources of ignition and to be screened or otherwise suitably protected to avoid oil spray or oil leakage onto the sources of ignition.

Precautions are to be taken to prevent any oil that may escape under pressure from any pump, filter or heater from coming into contact with heated surfaces.

e) Any relief valve of fuel oil and lubricating oil systems is to discharge to a safe position, such as an appropriate tank. See also item (a) of [9.1.7].

5.10.4 Provisions for flammable oil leakage containment

a) Tanks used for the storage of flammable oils together with their fittings are to be so arranged as to prevent spillages due to leakage or overfilling.

b) Drip trays with adequate drainage to contain possible leakage from flammable fluid systems are to be fitted:
   - under independent tanks (refer to Part B)
   - under burners
   - under purifiers and any other oil processing equipment
   - under pumps, heat exchangers and filters
   - under valves and all accessories subject to oil leakage
   - surrounding internal combustion engines.

c) The coaming height of drip trays is to suit the amount of potential oil spillage.

d) Where drain pipes are provided for collecting leakages, they are to be led to an appropriate drain tank.

5.10.5 Drain tank

a) The drain tank is not to form part of an overflow system and is to be fitted with an overflow alarm device.

b) In s required to be fitted with a double bottom, appropriate precautions are to be taken when the drain tank is constructed in the double bottom, in order to avoid flooding of the machinery space where drip trays are located, in the event of accidentally running aground.

5.10.6 Valves

All valves and cocks forming part of flammable oil systems are to be capable of being operated from readily accessible positions and, in machinery spaces, from above the working platform.

5.10.7 Level switches

Level switches fitted to flammable oil tanks are to be contained in a steel or other fire-resisting enclosure.

6 Bilge systems

6.1 Principle

6.1.1 General *(1/1/2025)*

An efficient bilge pumping system shall be provided, capable of pumping from and draining any watertight compartment other than a space permanently appropriated for the carriage of fresh water, water ballast, fuel oil and for which other efficient means of pumping are to be provided, under all practical conditions. Efficient means shall be provided for draining water from insulated holds.

Bilge pumping system is not intended at coping with water ingress resulting from structural or main sea water piping damage.

6.1.2 Availability of the bilge system

The bilge system is to be able to work while the other essential installations of the yacht, especially the fire-fighting installations, are in service.

6.1.3 Bilge and ballast systems *(1/1/2025)*

The arrangement of the bilge and ballast pumping system shall be such as to prevent the possibility of water passing from the sea and from water ballast spaces into the machinery spaces, or from one compartment to another.

Provisions shall be made to prevent any deep tank having bilge and ballast connections being inadvertently flooded from the sea or being discharged through a bilge pump when containing water ballast.

6.2 Design of bilge systems

6.2.1 General

a) The bilge pumping system is to consist of pumps connected to a bilge main line so arranged as to allow the draining of all spaces mentioned in [6.1.1] through bilge branches, distribution boxes and bilge suctions, except for some small spaces where individual suctions by means of hand pumps may be accepted as stated in [6.5.3] and [6.5.4].

b) If deemed acceptable by the Society, bilge pumping arrangements may be dispensed with in specific compartments provided the safety of the yacht is not impaired.

6.2.2 Number and distribution of bilge suctions

a) Draining of watertight spaces is to be possible, when the is on an even keel and either is upright or has a list of up to 5°, by means of at least:
   - two suctions in machinery spaces, including one branch bilge suction and one direct suction and, in addition, for spaces containing propulsion machinery, one emergency bilge suction
   - one suction in other spaces.

   See also [6.3.5].

b) Bilge suctions are to be arranged as follows:
   - wing suctions are generally to be provided except in the case of short and narrow compartments when a single suction ensures effective draining in the above conditions
   - in the case of compartments of unusual form, additional suctions may be required to ensure effective draining under the conditions mentioned in [6.2.2], item a).

c) In all cases, arrangements are to be made such as to allow a free and easy flow of water to bilge suctions.

6.2.3 Prevention of communication between spaces - Independence of the lines

a) Bilge lines are to be so arranged as to avoid inadvertent flooding of any dry compartment.

b) Bilge lines are to be entirely independent and distinct from other lines except where permitted in [5.4].

6.3 Draining of machinery spaces

6.3.1 General *(1/1/2025)*

Where all the propulsion machinery and main auxiliaries are located in a single watertight space, the bilge suctions are to be distributed and arranged in accordance with the provisions of [6.3.5].

6.3.2 Branch bilge suction

The branch bilge suction is to be connected to the bilge main.

6.3.3 Direct suction

The use of ejectors for pumping through the direct suction will be given special consideration.

6.3.4 Emergency bilge suction

a) The emergency bilge suction is to be led directly from the drainage level of the machinery space to a main circulating (or cooling) pump and fitted with a non-return valve.

b) In s where, in the opinion of the Society, the main circulating (or cooling) pump is not suitable for this purpose, the emergency bilge suction is to be led from the largest available independent power driven pump to the drainage level of the machinery space. Such a pump is not to be a bilge pump. Its capacity when the emergency suction is operating is to be at least equal to the required capacity of each bilge pump as determined in [6.5.4].

c) The emergency bilge suction is to be located at the lowest possible level in the machinery spaces.

6.3.5 Number and distribution of suctions in propulsion machinery spaces

a) In propulsion machinery spaces, bilge suctions are to include:
   - where the bottom of the space, bottom plating or top of the double bottom slope down to the centreline by more than 5°, at least two centreline suctions, i.e. one branch bilge suction and one direct suction, or
   - where the bottom of the space is horizontal or slopes down to the sides, at least two suctions, i.e. one branch bilge suction and one direct suction, on each side,
   - and one emergency bilge suction.

b) If the tank top is of a particular design or shows discontinuity, additional suctions may be required.

c) Where the propulsion machinery space is located aft, suctions are normally to be provided on each side at the fore end and, except where not practicable due to the shape of the space, on each side at the aft end of the space.

d) In electrically propelled s, provision is to be made to prevent accumulation of water under electric generators and motors.

6.3.6 Number and distribution of suctions in auxiliary machinery spaces

In auxiliary compartments, bilge suctions are to include:

- bilge branch suctions
- one direct suction.

6.4 Draining of dry spaces other than machinery spaces

6.4.1 General

a) Except where otherwise specified, bilge suctions are to be branch bilge suctions, i.e. suctions connected to a bilge main.

b) Draining arrangements of tanks are to comply with the provisions of [7].

6.4.2 Draining of cofferdams

a) All cofferdams are to be provided with suction pipes led to the bilge main.

b) Where cofferdams are divided by longitudinal watertight bulkheads or girders into two or more parts, a single suction pipe led to the aft end of each part is acceptable.

6.4.3 Draining of fore and aft peaks

a) Where the peaks are not used as tanks and bilge suctions are not fitted, drainage of both peaks may be effected by hand pump suction provided that the suction lift is well within the capacity of the pump and in no case exceeds 7,3 m.

b) Except where permitted in [5.3.3], the collision bulkhead is not to be pierced below the freeboard deck.

6.4.4 Draining of spaces above fore and aft peaks

a) Provision is to be made for the drainage of the chain lockers and watertight compartments above the fore peak tank by hand or power pump suctions.

b) Steering gear compartments or other small enclosed spaces situated above the aft peak tank are to be provided with suitable means of drainage, either by hand or power pump bilge suctions. However, in the case of rudder stock glands located below the summer load line, the bilge suctions of the steering gear compartment are to be connected to the main bilge system.

6.4.5 Draining of tunnels

a) Tunnels are to be drained by means of suctions connected to the main bilge system. Such suctions are generally to be located in wells at the aft end of the tunnels.

b) Where the top of the double bottom, in the tunnel, slopes down from aft to forward, an additional suction is to be provided at the forward end of this space.

6.4.6 Draining of refrigerated spaces

Provision is to be made for the continuous drainage of condensate in refrigerated and air cooler spaces. To this end, valves capable of blanking off the water draining lines of such spaces are not to be fitted, unless they are operable from an easily accessible place located above the load waterline.

6.5 Bilge pumps

6.5.1 Number and arrangement of pumps

a) At least two power pumps connected to the main bilge system are to be provided, one of which may be driven by the propulsion machinery. Such pumps are to be fitted in two different compartment and they are to be fed by two different sources of power supplies. The location of pumps, their individual power supplies and controls, including those for bilge valves, is to be such that, in the event of any one compartment being flooded, another pump is available to control any leakage to adjacent compartments. Hand driven pumps are not acceptable..

b) Bilge pumps driven by the propulsion machinery are not allowed on yachts exceeding 1000 gross tonnage.

c) Each pump may be replaced by a group of pumps connected to the bilge main, provided their total capacity meets the requirements specified in [6.5.4].

d) The two pumps are to have each its dedicated suction piping from each watertight compartment and its dedicated overboard dis-charge. The use of a common piping and/or a common overboard are acceptable provided that, where necessary, are fitted remote controlled valves so that it is possible to drain every watertight compartment with either pumps from outside the compartment where the main bilge pump and the manifold are located.

e) The second ("emergency") bilge pump may be the same pump as the emergency fire pump provided that they can satisfy the re-quirement of both the system. When a common piping is not used means are to be provided in order to drain every compartment di-rectly from the second pump.

f) The total number of pumps for bilge and fire system is to be at least 3

6.5.2 Use of ejectors

One of the pumps may be replaced by a hydraulic ejector connected to a high pressure water pump and capable of ensuring the drainage under similar conditions to those obtained with the other pump.

6.5.3 Use of bilge pumps for other duties

Bilge pumps may be used for other duties, such as fire, general service, sanitary service or ballast provided that:

- such duties are of intermittent nature
- any failure of the piping systems connected to the bilge pumps does not render the bilge system inoperable
- pumps are immediately available for bilge duty when necessary.

6.5.4 Capacity of the pumps

a) Each power bilge pump is to be capable of pumping water through the required main bilge pipe at a speed of not less than 2 m/s.

b) The capacity of each pump or group of pumps is not to be less than:

$$Q = 0{,}00565\ d^2$$

where:

Q : Minimum capacity of each pump or group of pumps, in m^3/h

d : Internal diameter, in mm, of the bilge main as defined in [6.6.1].

c) If the capacity of one of the pumps or one of the groups of pumps is less than the Rule capacity, the deficiency may be compensated by an excess capacity of the other pump or group of pumps; as a rule, such deficiency is not permitted to exceed 30% of the Rule capacity.

d) Where an ejector is used in lieu of a driven pump, its suction capacity is not to be less than the required capacity of the pump it replaces.

e) When fixed pressure water-spraying systems are fitted in closed vehicle spaces, the requirements contained in the guidelines developed by IMO (see Note 3) are to be duly considered.

Note 1: see resolution MSC.1/Circ. 1320 "Guidelines for the drainage of fire-fighting water from closed vehicle and ro-ro spaces and special category spaces of passenger and cargo ships"

6.5.5 Choice of the pumps

a) Bilge pumps are to be of the self-priming type. Centrifugal pumps are to be fitted with efficient priming means, unless an approved priming system is provided to ensure the priming of pumps under normal operating conditions.

b) Circulating or cooling water pumps connected to an emergency bilge suction need not be of the self-priming type.

c) Sanitary, ballast and general service pumps may be accepted as independent power bilge pumps if fitted with the necessary connections to the bilge pumping system.

6.5.6 Connection of power pumps

a) Bilge pumps and other power pumps serving essential services which have common suction or discharge are to be connected to the pipes in such a way that:
   - compartments and piping lines remain segregated in order to prevent possible intercommunication
   - the operation of any pump is not affected by the simultaneous operation of other pumps.

b) The isolation of any bilge pump for examination, repair or maintenance is to be made possible without impeding the operation of the remaining bilge pumps.

6.5.7 Electrical supply of submersible pump motors

a) Where submersible bilge pumps are provided, arrangements are to be made to start their motors from a convenient position above the bulkhead deck.

b) Where an additional local-starting device is provided at the motor of a permanently installed submersible bilge pump, the circuit is to be arranged to provide for the disconnection of all control wires therefrom at a position adjacent to the starter installed on the deck.

6.6 Size of bilge pipes

6.6.1 Bilge main line

a) The diameter of the bilge main is to be calculated according to the following formula:

$$d = 25 + 1,68\sqrt{L(B + D)}$$

where:

d : The internal diameter of the bilge main, in mm

L : Length of the is the length measured between perpendiculars taken at the extremities of the deepest subdivision load line, in m.

B : Breadth of the yacht is the extreme width from outside of frame to outside of frame at or below the deepest subdivision load line, in m.

D : Moulded depth of the to the bulkhead deck, in m, .

b) Where the bilge pumps are designed to pump from the machinery space only, the internal diameter d, in mm, of the bilge main may be less than that required in (a) but not less than that calculated with the following formula:

$$d = 35 + 3\sqrt{L_0(B + D)}$$

where:

L_0 : Length of the engine room, in m

B : Breadth of the , in m, as defined in a)

D : Moulded depth of the to the bulkhead deck, in m, as defined in a)

In any case, the internal section of the bilge main is not to be less than twice that of the bilge suction pipes determined from [6.6.3].

c) When fixed pressure water-spraying systems are fitted in closed vehicle spaces and closed ro-ro spaces, the requirements contained in the guidelines developed by IMO (see Note 2) are to be duly considered (see Note 3).

Note 1: see resolution MSC.1/Circ. 1320 "Guidelines for the drainage of fire-fighting water from closed vehicle and ro-ro spaces and special category spaces of passenger and cargo ships"

d) In no case is the actual internal diameter to be:
   - more than 5 mm smaller than that obtained from the formula given in a) or b), or

- less than 60 mm.

Relaxations may be considered for multihull.

6.6.2 Distribution box branch pipes

The cross-section of any branch pipe connecting the bilge main to a bilge distribution box is not to be less than the sum of the cross-sections required for the two largest branch suctions connected to this box. However, this cross-section need not exceed that of the bilge main.

6.6.3 Branch bilge suction pipes *(1/1/2025)*

a) The internal diameter, in mm, of pipes situated between distribution boxes and suctions in holds and machinery spaces is not to be less than the diameter given by the following formula:

$$d_1 = 25 + 2{,}16\sqrt{L_1(B + D)}$$

where:

B and D : as defined in [6.6.1]

L_1 : Length of the compartment, in m.

d_1 is not to be less than 50 mm and need not exceed 100 mm.

b) When fixed pressure water-spraying systems are fitted in closed vehicle spaces, the requirements contained in the guidelines developed by IMO (see Note 1) are to be duly considered (see Note 2).

Note 1: see resolution MSC.1/Circ. 1320 "Guidelines for the drainage of fire-fighting water from closed vehicle and ro-ro spaces and special category spaces of passenger and cargo ships".

6.6.4 Direct suctions other than emergency suctions

a) Direct suctions are to be suitably arranged and those in a machinery space are to be of a diameter not less than that required for the bilge main.

b) In yachts having separate machinery spaces of small dimensions, the size of the direct suctions need not exceed that given in [6.6.3] for branch bilge suctions.

6.6.5 Emergency suctions in machinery spaces

a) The diameter of emergency bilge suction pipes is to be the same as the diameter of the pump inlet :

b) Where the emergency suction is connected to a pump other than a main circulating or cooling pump, the suction is to be the same diameter as the main inlet of the pump.

6.6.6 Bilge suctions from tunnels

Bilge suction pipes to tunnel wells are not to be less than 65 mm in diameter. In yachts up to 60 metres in length, this diameter may be reduced to 50 mm.

6.7 Bilge accessories

6.7.1 Drain valves on watertight bulkheads

a) The fitting of drain valves or similar devices is not allowed on the collision bulkhead.

b) On other watertight bulkheads, the fitting of drain valves or similar devices is allowed unless practical alternative draining means exist. Such valves are to be easily accessible at all times and operable from above the freeboard deck. Means indicating whether the valves are open or closed are to be provided.

6.7.2 Screw-down non-return valves

a) Accessories are to be provided to prevent intercommunication of compartments or lines which are to remain segregated from one another. For this purpose, non-return devices are to be fitted:
   - on the pipe connections to bilge distribution boxes or to the alternative valves, if any
   - on direct and emergency suctions in machinery spaces
   - on the suctions of pumps which also have connections from the sea or from compartments normally intended to contain liquid
   - on flexible bilge hose connections
   - on the suctions of water bilge ejectors
   - at the open end of bilge pipes passing through deep tanks
   - in compliance with the provisions for the prevention of progressive flooding, if applicable.

b) Screw-down and other non-return valves are to be of a recognised type which does not offer undue obstruction to the flow of water.

6.7.3 Bilge Alarm

A bilge level alarm is to be fitted. Such an alarm is to provide an audible and visual warning in the Master's cabin and in the wheel-house. The audible and visual alarm may be accepted elsewhere if it is considered that such a location may by more appropriate

6.7.4 Strum boxes

a) In compartments other than machinery spaces and shaft tunnels, the open ends of bilge suction pipes are to be fitted with strum boxes or strainers having holes not more than 10 mm in diameter. The total area of such holes is to be not less than twice the required cross-sectional area of the suction pipe.

b) Strum boxes are to be so designed that they can be cleaned without having to remove any joint of the suction pipe.

6.7.5 Bilge wells

a) The wells provided for draining the various compartments are to be made of steel plate and their capacity is not to be less than 0,15 m^3. In small compartments, smaller cylindrical wells may be fitted.

b) Bilge wells are to comply with the relevant provisions of Part B.

6.7.6 Liquid sealed traps

a) The bilge line of refrigerated spaces is to be provided with liquid sealed traps of adequate size arranged for easy cleaning and refilling with brine. These traps are to be fitted with removable grids intended to hold back waste products when defrosting.

b) Where drain pipes from separate refrigerated rooms join a common main, each of these pipes is to be provided with a liquid sealed trap.

c) As a general rule, liquid sealed traps are to be fitted with non-return valves. However, for refrigerated spaces not situated in the bottom, non-return valves may be omitted, provided this arrangement does not impair the integrity of the watertight subdivision.

6.8 Bilge piping arrangement

6.8.1 Passage through double bottom compartments

Bilge pipes are not to pass through double bottom compartments. If such arrangement is unavoidable, the parts of bilge pipes passing through double bottom compartments are to comply with [5.2.3].

6.8.2 Passage through deep tanks *(1/1/2025)*

The parts of bilge pipes passing through deep tanks intended to contain water ballast, fresh water or fuel oil are normally to be contained within pipe tunnels. Alternatively, such parts are to comply with [5.2.3]; the number of joints is to be as small as possible. These pipes are to be provided at their ends in the holds with non-return valves.

6.8.3 Provision for expansion

Where necessary, bilge pipes inside tanks are to be fitted with expansion bends. Sliding joints are not permitted for this purpose.

6.8.4 Connections

Connections used for bilge pipes passing through tanks are to be welded joints or reinforced welded flange connections.

6.8.5 Access to valves and distribution boxes

All distribution boxes and manually operated valves in connection with the bilge pumping arrangement shall be in positions which are accessible under ordinary circumstances

Hand-wheels of valves controlling emergency bilge suctions are to be readily accessible and preferably above the floor.

7 Ballast systems

7.1 Design of ballast systems

7.1.1 Independence of ballast lines

Ballast lines are to be entirely independent and distinct from other lines except where permitted in [5.4].

7.1.2 Prevention of undesirable communication between spaces or with the sea

Ballast systems in connection with bilge systems are to be so designed as to avoid any risk of undesirable communication between spaces or with the sea. See [6.1.3].

7.1.3 Alternative carriage of ballast water and fuel oil

a) Oily ballast systems serving tanks intended for alternative carriage of fuel oil and water ballast are to be independent of clean ballast systems:
   - serving the other ballast tanks, or
   - connected to tanks also intended to contain feed water.

b) Where tanks are intended to alternatively contain fuel oil and ballast water, the relevant piping systems are to be arranged in accordance with [11.4.4].

7.1.4 Alternative carriage of ballast water

Holds and deep tanks designed for the alternative carriage of water ballast or fuel oil are to have their filling and suction lines provided with blind flanges or appropriate change-over devices to prevent any mishandling.

7.1.5 Alternative carriage of ballast water and feed water

Where tanks are intended to alternatively contain ballast water and feed water, the suction line is to have removable elbows for connection to the ballast and feed water systems, so as to avoid any accidental interconnection between the two systems due to manoeuvring error.

7.2 Ballast pumping arrangement

7.2.1 Filling and suction pipes

a) All tanks including aft and fore peak and double bottom tanks intended for ballast water are to be provided with suitable filling and suction pipes connected to special power driven pumps of adequate capacity.

b) Small tanks used for the carriage of domestic fresh water may be served by hand pumps.

c) Suctions are to be so positioned that the transfer of sea water can be suitably carried out in the normal operating conditions of the yacht. In particular, two suctions may be required in long compartments.

7.2.2 Pumps

At least two power pumps connected to the ballast system are to be provided, one of which may be driven by the propulsion machinery.

Bilge pumps may be used for ballast water transfer provided the provisions of [6.5.3] are fulfilled.

7.2.3 Passage of ballast pipes through tanks

If not contained in pipe tunnels, the parts of ballast pipes passing through tanks intended to contain fresh water or fuel oil are to comply with [5.2.3].

7.3 Ballast Water Management Systems

7.3.1

When a Ballast water Management (treatment) system is installed on board, the requirements in App 4 are to be complied with.

8 Scuppers and sanitary discharges

8.1 Application

8.1.1

a) This Article applies to:
   - scuppers and sanitary discharge systems, and
   - discharges from sewage tanks.

b) Discharges in connection with machinery operation are dealt with in [2.7].

8.2 Principle

8.2.1

a) Scuppers, sufficient in number and suitable in size, are to be provided to permit the drainage of water likely to accumulate in the spaces which are not located in the 's bottom. The Society may permit the means of drainage to be dispensed with in any particular compartment if it is satisfied that, by reason of size or internal subdivision of such space, the safety of the is not impaired.

b) The number of scuppers and sanitary discharge openings in the shell plating is to be reduced to a minimum either by making each discharge serve as many as possible of the sanitary and other pipes, or in any other satisfactory manner.

8.3 Drainage from spaces below the freeboard deck or within enclosed superstructures and deckhouses on the freeboard deck

8.3.1 Normal arrangement *(1/1/2025)*

Scuppers and sanitary discharges from spaces below the freeboard deck or from within superstructures and deckhouses on the freeboard deck fitted with weathertight doors are to be led to:

a) a suitable space, or spaces, of appropriate capacity, having a high water level alarm and provided with suitable pumping arrangements for discharge overboard. In addition, it is to be ensured that:

   1) the number, size and arrangement of the scuppers are such as to prevent unreasonable accumulation of free water,

   2) the pumping arrangements take account of the requirements for any fixed pressure water-spraying fire-extinguishing system

   3) water contaminated with petrol or other dangerous substances is not drained to machinery spaces or other spaces where sources of ignition may be present, and

b) suitable sanitary tanks in the case of sanitary discharges.

8.3.2 Alternative arrangement

The scuppers and sanitary discharges may be led overboard provided that:

- the freeboard deck edge is not immersed when the heels 5°, and
- the inboard end of the discharge is located above the load waterline formed by a 5° heel, to port or starboard, at a draft corresponding to the assigned summer freeboard, and,
- the pipes are fitted with efficient means of preventing water from passing inboard in accordance with [8.6] and [8.7].

8.4 Drainage of superstructures or deckhouses not fitted with efficient weathertight doors

8.4.1

Scuppers leading from superstructures or deckhouses not fitted with doors are to be led overboard, and subject to [8.3.2].

8.5 Drainage of spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion

8.5.1 Prevention of build-up of free surfaces

In spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion and fitted with a fixed pressure water-spraying fire-extinguishing system, the drainage arrangement is to be in compliance with the requirements contained in the guidelines developed by IMO (see Note 1) such as to prevent the build-up of free surfaces.

Note 1: see resolution MSC.1/Circ. 1320 "Guidelines for the drainage of fire-fighting water from closed vehicle and ro-ro spaces and special category spaces of passenger and cargo ships".

8.5.2 Scupper draining

Scuppers from spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion are not to be led to machinery spaces or other places where sources of ignition may be present.

8.6 Arrangement of discharges - General

8.6.1 Arrangement of discharges through the shell more than 450 mm below the freeboard deck or less than 600 mm above the summer load waterline

Scupper and discharge pipes originating at any level and penetrating the shell either more than 450 millimetres below the freeboard deck or less than 600 millimetres above the summer load waterline are to be provided with a non-return valve at the shell. Unless required by [8.7], this valve may be omitted if the piping is of substantial thickness, as per Tab 22.

8.6.2 Arrangement of discharges through the shell less than 450 mm below the freeboard deck and more than 600 mm above the summer load waterline

Scupper and discharge pipes penetrating the shell less than 450 millimetres below the freeboard deck and more than 600 millimetres above the summer load waterline are not required to be provided with a non-return valve at the shell, except for the cases indicated in [8.7].

8.7 Arrangement of discharges from enclosed spaces below the freeboard deck or on the freeboard deck

8.7.1 Normal arrangement

Each separate discharge led though the shell plating from enclosed spaces below the freeboard deck is to be provided with one automatic non-return valve fitted with positive means of closing it from above the freeboard deck or one automatic non-return valve and one sluice valve controlled from above the freeboard deck.

The requirements for non-return valves are applicable only to those discharges which remain open during the normal operation of the yacht; For discharges which are to be kept closed at sea (such as gravity drain from topside ballast tanks), a single screw down valve operated from above the freeboard deck is acceptable.

Where a valve with positive means of closing is fitted, the operating position above the freeboard deck shall always be readily accessible and means shall be provided for indicating whether the valve is open or closed.

The position of the inboard end of discharges is related to the timber summer load waterline when a timber freeboard is assigned.

8.7.2 Alternative arrangement when the inboard end of the discharge pipe is above the summer waterline by more than 0,01 L

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0,01 L, the discharge may have two automatic non-return valves without positive means of closing, provided that the inboard valve:

- is above the deepest subdivision load line, and
- is always accessible for examination under service conditions.

If the inboard non-return valve is not according to the above, a valve with positive means of closing controlled locally is to be fitted in between the shell plating and the inboard valve.

8.7.3 Alternative arrangement when the inboard end of the discharge pipe is above the summer waterline by more than 0,02 L

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0,02 L, a single automatic non-return valve without positive means of closing may be accepted subject to the approval of the Society.

8.7.4 Arrangement of discharges through manned machinery spaces

Where sanitary discharges and scuppers are lead overboard through the shell in way of manned machinery spaces, the fitting at the shell of a locally operated positive closing valve together with a non-return valve inboard may be accepted. The operating position of the valve will be given special consideration by the Society.

8.8 Summary table of overboard discharge arrangements

8.8.1 *(1/1/2025)*

The various arrangements acceptable for scuppers and sanitary overboard discharges are summarised in Table 22.1 of Regulation 22 of the 1966 Convention on Load Line shown in Fig 3.

8.9 Valves and pipes

8.9.1 Materials

a) All shell fittings and valves are to be of steel, bronze or other ductile material. Valves of ordinary cast iron or similar material are not acceptable. All scupper and discharge pipes are to be of steel or other ductile material. Refer to [2.1].

b) Plastic is not to be used for the portion of discharge line from the shell to the first valve.

8.9.2 Thickness of pipes

a) The thickness of scupper and discharge pipes led to the bilge or to draining tanks is not to be less than that required in [2.2].

b) The thickness of scupper and discharge pipes led to the shell is not to be less than the minimum thickness given in Tab 22, for the part between the shell plating and the outermost valve.

8.9.3 Operation of the valves

a) Where valves are required to have positive means of closing, such means is to be readily accessible and provided with an indicator showing whether the valve is open or closed.

b) Where plastic pipes are used for sanitary discharges and scuppers, the valve at the shell is to be operated from outside the space in which the valve is located.

Where such plastic pipes are located below the summer waterline (timber summer load waterline), the valve is to be operated from a position above the freeboard deck.

Refer also to App 3.

8.10 Arrangement of scuppers and sanitary discharge piping

8.10.1 Overboard discharges and valve connections

a) Overboard discharges are to have pipe spigots extending through the shell plate and welded to it, and are to be provided at the internal end with a flange for connection to the valve or pipe flange.

b) Valves may also be connected to the hull plating in accordance with the provisions of [2.7.3], item c).

Figure 3 : Overboard discharge arrangement

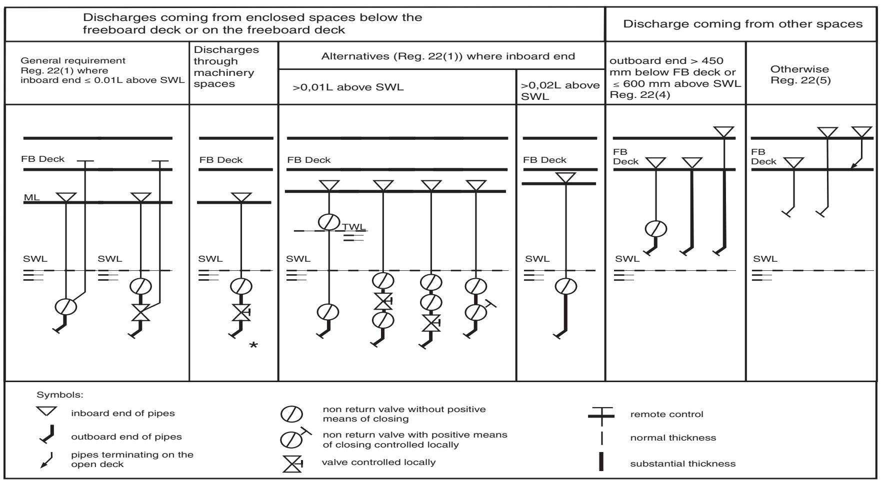


Table 22 : Minimum thickness of scupper and discharge pipes led to the shell

External diameter of the pipe d (mm)	Column 1 substantial thickness (mm)	Column 2 normal thickness (mm)
d ≤ 80,0	7,00	4,50
155	9,25	4,50
180	10,00	5,00
220	12,50	5,80
230 ≤ d	12,50	6,00
Note 1: Intermediate sizes may be determined by interpolation.		

8.10.2 Passage through tanks

a) As a rule, scupper and sanitary discharge pipes are not to pass through fuel oil tanks.

b) Where scupper and discharge pipes pass unavoidably through fuel oil tanks and are led through the shell within the tanks, the thickness of the piping is not to be less than that given in Tab 23, column 1 (substantial thickness). It need not, however, exceed the thickness of the adjacent Rule shell plating.

c) Scupper and sanitary discharge pipes are normally not to pass through fresh and drinking water tanks.

8.10.3 Passage through watertight bulkheads or decks

a) The intactness of machinery space bulkheads and of tunnel plating required to be of watertight construction is not to be impaired by the fitting of scuppers discharging to machinery spaces or tunnels from adjacent compartments which are situated below the freeboard deck.

b) Such scuppers may, however, be led into a strongly constructed scupper drain tank situated in the machinery space or tunnel, but close to the above-mentioned adjacent compartments and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

8.10.4 Discharge in refrigerated spaces

No scupper pipe from non-refrigerated spaces is to discharge in refrigerated spaces.

8.10.5 Discharge from galleys and their stores

Discharges from galleys and their stores are to be kept separate from other discharges and be drained overboard or in separate drainage tanks; alternatively, discharges are to be provided with adequate devices against odours and overflow.

8.10.6 Discharge from aft spaces

Where spaces located aft of the aft peak bulkhead not intended to be used as tanks are drained by means of scuppers discharging to the shaft tunnel, the provisions of [6.4.4], item c) are to be complied with.

8.10.7 Scupper tank

a) The scupper tank air pipe is to be led to above the freeboard deck.

b) Provision is to be made to ascertain the level of water in the scupper tank.

9 Air, sounding and overflow pipes

9.1 Air pipes

9.1.1 Principle

Air pipes are to be fitted to all tanks, double bottoms, cofferdams, tunnels and other compartments which are not fitted with alternative ventilation arrangements, in order to allow the passage of air or liquid so as to prevent excessive pressure or vacuum in the tanks or compartments, in particular in those which are fitted with piping installations. Their open ends are to be so arranged as to prevent the free entry of sea water in the compartments.

9.1.2 Number and position of air pipes

a) Air pipes are to be so arranged and the upper part of compartments so designed that air or gas likely to accumulate at any point in the compartments can freely evacuate.

b) Air pipes are to be fitted opposite the filling pipes and/or at the highest parts of the compartments, the yacht being assumed to be on an even keel.

c) In general, two air pipes are to be fitted for each compartment, except in small compartments, where only one air pipe may be accepted. When the top of the compartment is of irregular form, the position of air pipes will be given special consideration by the Society.

d) Where only one air pipe is provided, it is not to be used as a filling pipe.

9.1.3 Location of open ends of air pipes

a) Air pipes of double bottom compartments, tunnels, deep tanks and other compartments which can come into contact with the sea or be flooded in the event of hull damage are to be led to above the bulkhead deck or the freeboard deck.

Note 1: In yachts not provided with a double bottom, air pipes of small cofferdams or tanks up to 1 m3 not containing fuel oil may discharge within the space concerned.

b) Air pipes of tanks intended to be pumped up are to be led to the open above the bulkhead deck or the freeboard deck.

c) Air pipes of tanks other than oil tanks may discharge through the side of the superstructure contributing to buoyancy.

d) The air pipe of the scupper tank is to be led to above freeboard deck.

e) The location of air pipes for flammable oil tanks is also to comply with [9.1.7].

9.1.4 Height of air pipes

a) The height of air pipes extending above the freeboard deck or superstructure deck from the deck to the point where water may have access below is to be at least what indicated in Pt B, Ch 1, Sec 1, [5.11].

b) Where these heights may interfere with the working of the yacht, a lower height may be approved, provided the Society is satisfied that this is justified by the closing arrangements and other circumstances. Satisfactory means which are permanently attached are to be provided for closing the openings of the air pipes.

c) The height of air pipes may be required to be increased on yachts for the purpose of compliance with buoyancy calculations.

d) The height of air pipes discharging through the side of the superstructure contributing to buoyancy is to be at least 2,3 m above the summer load waterline.

9.1.5 Fitting of closing appliances

a) Satisfactory appliances which are permanently attached are to be provided for closing the openings of air pipes in order to prevent the free entry of water into the spaces concerned.

b) Closing appliances are to be of automatic type in the following cases:
   - when fitted on exposed parts of freeboard deck and first superstructure deck,
   - where, with the at its summer load waterline, the openings are immersed at an angle of heel of 40° or, at the angle of down-flooding if the latter is less than 40°,
   - where, as per [9.1.3], item c), air pipes terminate in enclosed spaces,
   - where, as per [9.1.4], item b), air pipes have a height lower than that required in [9.1.4], item a),

c) Automatic closing appliances are to be of a type approved by the Society. Requirements for type tests are given in [17.2.2].

9.1.6 Design of closing appliances

a) When closing appliances are requested to be of an automatic type by these Rule, they are to comply with the following:
   - they are to be capable of preventing the free entry of water into the tanks;
   - they are to allow the passage of air or liquid to prevent excessive pressure or vacuum coming on the tank;
   - they are to be so designed that they withstand both ambient and working conditions up to an inclination of -40° to +40° without failure or damage;
   - they are to be so designed as to allow inspection of the closure and the inside of the casing as well as changing of the seals;
   - where they are of the float type, suitable guides are to be provided to ensure unobstructed operation under all working conditions of heel and trim up to an inclination of -40° to +40°;
   - efficient ball or float seating arrangements are to be provided for the closures. Bars, a cage or other devices are to be provided to prevent the ball or float from contacting the inner chamber in its normal state and made in such a way that the ball or float is not damaged when subjected to water impact due to a tank being overfilled;
   - they are to be self-draining;

- the clear area through an air pipe closing appliance is to be at least equal to the area of the inlet;
- the maximum allowable tolerances for wall thickness of floats is not to exceed ±10% of the nominal thickness;
- their casings are to be of approved metallic materials adequately protected against corrosion;
- closures and seats made of non-metallic materials are to be compatible with the media to be carried in the tank and with sea water at ambient temperatures between -25°C and 85°C;
- the inner and outer chambers of an automatic air pipe head are to be of a minimum thickness of 6 mm. Where side covers are provided and their function is integral to providing functions of the closing device as outlined above, they shall have a minimum wall thickness of 6 mm. If the air pipe head can meet the tightness test in the "Rules for type approval and testing of air pipe closing devices" without the side covers attached, then the side covers are not considered to be integral to the closing device, in which case a wall thickness less than 6 mm can be acceptable for side covers;
- for galvanised steel air pipe heads, the zinc coating is to be applied by the hot method and the thickness is to be 70 to 100 microns;
- for areas of the head susceptible to erosion (e.g. those parts directly subjected to ballast water impact when the tank is being pressed up, for example the inner chamber area above the air pipe, plus an overlap of 10° or more either side), an additional harder coating is to be applied. This is to be an aluminium bearing epoxy, or other equivalent, coating, applied over the zinc.

b) Where closing appliances are not of an automatic type, provision is to be made for relieving vacuum when the tanks are being pumped out. For this purpose, a hole of approximately 10 mm in diameter may be provided in the bend of the air pipe or at any other suitable position in the closing appliance.

9.1.7 Special arrangements for air pipes of flammable oil tanks

a) Air and overflow pipes and relief valves of fuel oil and thermal oil systems are to discharge to a position on the open deck where there is no risk of fire or explosion from the emergence of oils and vapour.

The open ends are to be fitted with flame screens made of corrosion resistant material and readily removable for cleaning and replacement. The clear area of such screens is not to be less than the cross-sectional area of the pipe.

b) Air pipes of lubricating or hydraulic oil storage tanks not subject to flooding in the event of hull damage may be led to machinery spaces, provided that in the case of overflowing the oil cannot come into contact with electrical equipment, hot surfaces or other sources of ignition.

c) The location and arrangement of vent pipes for fuel oil service, settling and lubrication oil tanks are to be such that in the event of a broken vent pipe there is no risk of ingress of seawater or rainwater.

d) Air pipes of fuel oil service, settling and lubrication oil tanks likely to be damaged by impact forces are to be adequately reinforced.

e) Where seawater or rainwater may enter fuel oil service, settling and lubrication oil tanks through broken air pipes, arrangements such as water traps with:

- automatic draining, or
- alarm for water accumulation

are to be provided.

9.1.8 Construction of air pipes

a) Where air pipes to ballast and other tanks extend above the freeboard deck or superstructure deck, the exposed parts of the pipes are to be of substantial construction, with a minimum wall thickness of at least:

- 6,0 mm for pipes of 80 mm or smaller external diameter
- 8,5 mm for pipes of 165 mm or greater external diameter,

Intermediate minimum thicknesses may be determined by linear interpolation.

b) Air pipes with height exceeding 900 mm are to be additionally supported.

c) In each compartment likely to be pumped up, and where no overflow pipe is provided, the total cross-sectional area of air pipes is not to be less than 1,25 times the cross-sectional area of the corresponding filling pipes.

d) The internal diameter of air pipes is not to be less than 50 mm, except for tanks of less than 2 m^3.

9.1.9 Green sea loads

The requirements in [9.1.9] and in [9.1.10] apply to strength checks of air pipes and their closing devices located within the forward quarter length of the , for s of length L 80 m or greater, where the height of the exposed deck in way of the item is less than 0,1L or 22 m above the summer load waterline, whichever is the lesser.

The pressures p, in kN/m^2 acting on air pipes and their closing devices may be calculated from:

$p = 0,5\ r\ V^2\ C_d\ C_s\ C_p$

where:

L : length as defined in Pt B, Ch 1, Sec 2, [3.1]

r : density of sea water (1,025 t/m³)

V : velocity of water over the fore deck

= 13,5m/sec for d £ 0,5 d_1

$$= 13,5\sqrt{2\left(1-\frac{d}{d_1}\right)}\ \text{m/sec}$$

for 0,5 d_1 < d < d_1

d : distance from summer load waterline to exposed deck

d_1 : 0,1L or 22 m whichever is the lesser

C_d : shape coefficient

= 0,5 for pipes, 1,3 for air pipes in general, 0,8 for an air pipe of cylindrical form with its axis in the vertical direction.

C_s : slamming coefficient (3,2)

C_p : protection coefficient:

- (0,7) for pipes located immediately behind a breakwater or forecastle,
- (1,0) elsewhere and immediately behind a bulwark.

Forces acting in the horizontal direction on the pipe and its closing device may be calculated from the pressure specified in this requirement using the largest projected area of each component.

9.1.10 Strength Requirements

These requirements are additional to those specified in [9.1.6] a), in [17.2.2] and in [9.1.8] a).

a) Bending moments and stresses in air 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 0,8 s_y, where s_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 of 2,0 mm is then to be applied to the net section.

b) For standard air pipes of 760 mm height closed by heads of not more than the tabulated projected area, pipe thicknesses and bracket heights are specified in Tab 24.

Where brackets are required, three or more radial brackets are to be fitted. Brackets are to be of at least 8 mm gross thickness, minimum 100 mm in length and height according to Tab 24, 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 [9.1.9] are to be applied, and means of support determined in order to comply with the requirements specified in a). Where fitted, brackets are to be of suitable thickness and length according to their height. Pipe thickness is not to be taken less than as indicated in [9.1.8] a).

d) All component parts and connections of the air pipe are to be capable of withstanding the loads defined in [9.1.9].

Table 23 : 760 mm Air Pipe Thickness and Bracket Standards

Nominal pipe diameter (mm)	Minimum fitted gross thickness (mm)	Maximum projected area of head (cm²)	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

(1) Brackets (see [9.1.10]) 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 1: For other air pipe heights, the relevant requirements in [9.1.10] are to be applied.

Nominal pipe diameter (mm)	Minimum fitted gross thickness (mm)	Maximum projected area of head (cm^2)	Height **(1)** of brackets (mm)
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)**

(1) Brackets (see [9.1.10]) 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 1: For other air pipe heights, the relevant requirements in [9.1.10] are to be applied.

9.2 Sounding pipes

9.2.1 Principle

a) Sounding devices are to be fitted to tanks intended to contain liquids as well as to all compartments which are not readily accessible at all times.

b) For compartments normally intended to contain liquids, the following systems may be accepted in lieu of sounding pipes:
- a level gauge of an approved type efficiently protected against shocks, or
- a remote level gauging system of an approved type, provided an emergency means of sounding is available in the event of failure affecting such system.

9.2.2 Position of sounding pipes

Sounding pipes are to be located as close as possible to suction pipes.

9.2.3 Termination of sounding pipes

a) As a general rule, sounding pipes are to end above the bulkhead deck or the freeboard deck in easily accessible places and are to be fitted with efficient, permanently attached, metallic closing appliances.

b) In machinery spaces and tunnels, where the provisions of a) cannot be satisfied, short sounding pipes led to readily accessible positions above the floor and fitted with efficient closing appliances may be accepted.

In s required to be fitted with a double bottom, such closing appliances are to be of the self-closing type.

9.2.4 Special arrangements for sounding pipes of flammable oil tanks

a) Where sounding pipes are used in flammable (except lubricating) oil systems, they are to terminate in the open air, where no risk of ignition of spillage from the sounding pipe might arise. In particular, they are not to terminate in passenger or crew spaces. As a general rule, they are not to terminate in machinery spaces. However, where the Society considers that this requirement is impracticable, it may permit termination in machinery spaces on condition that the following provisions are satisfied:
   1) in addition, an oil-level gauge is provided meeting the provisions of [2.7.2]
   2) the sounding pipes terminate in locations remote from ignition hazards unless precautions are taken, such as the fitting of effective screens, to prevent the fuel oil in the case of spillage through the terminations of the sounding pipes from coming into contact with a source of ignition
   3) the terminations of sounding pipes are fitted with self-closing blanking devices and with a small diameter self-closing control cock located below the blanking device for the purpose of ascertaining before the blanking device is opened that fuel oil is not present. Provision is to be made so as to ensure that any spillage of fuel oil through the control cock involves no ignition hazard.

b) For lubricating oil and fuel oil leakage tanks less than 2 m^3, the oil-level gauge mentioned in a).1 and the control cock mentioned in a).3 need not be provided on condition that the sounding pipes are fitted with appropriate means of closure.

c) Short sounding pipes may be used for tanks other than double bottom tanks without the additional closed level gauge provided an overflow system is fitted.

9.2.5 Closing appliances

a) Self-closing appliances are to be fitted with cylindrical plugs having counterweights such as to ensure automatic closing.

b) Closing appliances not required to be of the self-closing type may consist of a metallic screw cap secured to the pipe by means of a chain or a shut-off valve.

9.2.6 Construction of sounding pipes

a) Sounding pipes are normally to be straight. If it is necessary to provide bends in such pipes, the curvature is to be as small as possible to permit the ready passage of the sounding apparatus.

b) The sounding arrangement of compartments by means of bent pipes passing through other compartments will be given special consideration by the Society. Such an arrangement is normally accepted only if the compartments passed through are cofferdams or are intended to contain the same liquid as the compartments served by the sounding pipes.

c) Bent portions of sounding pipes are to have reinforced thickness and be suitably supported.

d) The internal diameter of sounding pipes is not to be less than 32 mm. Where sounding pipes pass through refrigerated spaces, or through the insulation of refrigerated spaces in which the temperature may be below 0°C, their internal diameter is to be at least 60 mm.

e) Doubling plates are to be placed under the lower ends of sounding pipes in order to prevent damage to the hull. When sounding pipes with closed lower ends are used, the closing plate is to have reinforced scantlings.

9.3 Overflow pipes

9.3.1 Principle

Overflow pipes are to be fitted to tanks:

- which can be filled by pumping and are designed for a hydrostatic pressure lower than that corresponding to the height of the air pipe, or
- where the cross-sectional area of air pipes is less than that prescribed in [9.1.8], item c).

9.3.2 Design of overflow systems

a) Overflow pipes are to be led:
   - either outside,
   - or, in the case of fuel oil or lubricating oil, to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

b) Where tanks containing the same or different liquids are connected to a common overflow system, the arrangement is to be such as to prevent any risk of:
   - intercommunication between the various tanks due to movements of liquid when emptying or filling, or due to the inclination of the yacht
   - overfilling of any tank from another assumed flooded due to hull damage.

   For this purpose, overflow pipes are to be led to a high enough point above the deepest load waterline or, alternatively, non-return valves are to fitted where necessary.

c) Arrangements are to be made so that a compartment cannot be flooded from the sea through the overflow in the event of another compartment connected to the same overflow main being bilged. To this end, the openings of overflow pipes discharging overboard are as a rule to be placed above the deepest load waterline and are to be fitted where necessary with non-return valves on the plating, or, alternatively, overflow pipes from tanks are to be led to a point above the deepest load waterline.

d) Where tanks alternately containing fuel oil and ballast water are connected to a common overflow system, arrangements are to be made to prevent the ballast water overflowing into the tanks containing fuel oil and vice-versa.

e) Additional requirements for s subject to damage stability checks are given in [5.5.3].

9.3.3 Overflow tanks

a) Overflow tanks are to have a capacity sufficient to receive the delivery of the pumps for at least 10 minutes.

b) Overflow tanks are to be fitted with an air pipe complying with [9.1] which may serve as an overflow pipe for the same tank. When the vent pipe reaches a height exceeding the design head of the overflow tank, suitable means are to be provided to limit the actual hydrostatic head on the tank.

   Such means are to discharge to a position which is safe in the opinion of the Society.

c) An alarm device is to be provided to give warning when the oil reaches a predetermined level in the tank, or alternatively, a sight-flow glass is to be provided in the overflow pipe to indicate when any tank is overflowing. Such sight-flow glasses are only to be placed on vertical pipes and in readily visible positions.

9.3.4 Specific requirements for construction of overflow pipes

a) The internal diameter of overflow pipes is not to be less than 50 mm.

b) In each compartment which can be pumped up, the total cross-sectional area of overflow pipes is not to be less than 1,25 times the cross-sectional area of the corresponding filling pipes.

c) The cross-sectional area of the overflow main is not to be less than the aggregate cross-sectional area of the two largest pipes discharging into the main.

9.4 Constructional requirements applying to sounding, air and overflow pipes

9.4.1 Materials

a) Sounding, air and overflow pipes are to be made of steel or any other material approved for the application considered.

b) Exposed parts of sounding, air and overflow pipes are to be made of approved metallic materials.

9.4.2 Minimum thickness of steel pipes

The minimum thickness of sounding, air and overflow steel pipes is given in Tab 25.

Table 24 : Minimum wall thickness of sounding, air and overflow pipes

External diameter (mm)	Minimum wall thickness (mm) **(1)**
up to 168,3	4,5
177,8	5,0
193,7	5,4
219,1	5,9
above 244,5	6,3

(1) Applies only to structural tanks.
For independent tanks, refer to Pt B.

9.4.3 Passage of pipes through certain spaces

When sounding, air and overflow pipes made of steel are permitted to pass through ballast tanks or fuel oil tanks, they are to comply with [5.2.3]

9.4.4 Self-draining of pipes

Air pipes and overflow pipes are to be so arranged as to be self-draining when the yacht is on an even keel.

9.4.5 Name plates

Nameplates are to be fixed at the upper part of air pipes and sounding pipes.

10 Cooling systems

10.1 Application

10.1.1 This article applies to all cooling systems using the following cooling media:

- sea water
- fresh water
- lubricating oil.

Air cooling systems will be given special consideration.

10.2 Principle

10.2.1 General

Sea water and fresh water cooling systems are to be so arranged as to maintain the temperature of the cooled media (lubricating oil, hydraulic oil, charge air, etc.) for propulsion machinery and essential equipment within the manufacturers' recommended limits during all operations, including starting and manoeuvring, under the inclination angles and the ambient conditions specified in Sec 1.

10.2.2 Availability of the cooling system

The cooling system is to be so designed that, in the event of one essential component being inoperative, the cooling of propulsion machinery is maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the yacht is not impaired.

10.3 Design of sea water cooling systems

10.3.1 General

a) Sea water cooling of the propulsion engines, auxiliary engines and other essential equipment is to be capable of being supplied by two different means.

b) Where required, standby pumps are not to be connected to the sea inlet serving the other sea water pumps, unless permitted under [10.6.1], item b).

10.3.2 Centralised cooling systems

a) In the case of centralised cooling systems, i.e. systems serving a group of propulsion engines and/or auxiliary engines, reduction gears, compressors and other essential equipment, the following sea water pumps are to be arranged:
   - one main cooling water pump, which may be driven by the engines, of a capacity sufficient to provide cooling water to all the equipment served
   - one independently driven standby pump of at least the same capacity

b) Where the cooling system is served by a group of identical pumps, the capacity of the standby pump needs only to be equivalent to that of each of these pumps.

c) Ballast pumps or other suitable sea water pumps of appropriate capacity may be used as standby pumps, provided arrangements are made against overpressure in the cooling system.

d) In yachts having one or more propulsion engines, each with an output not exceeding 375 kW, the independent standby pump may be replaced by a complete spare pump of appropriate capacity ready to be connected to the cooling circuit.

e) In cases of centralised cooling systems serving only a group of auxiliary engines, the second means of cooling may consist of a connection to a cooling water pump serving the propulsion plant, provided such pump is of sufficient capacity to provide cooling water to both propulsion plant and auxiliary engines.

10.3.3 Individual cooling of propulsion engines

a) Individual cooling systems of propulsion engines are to include at least:
   - one main cooling water pump, which can be driven by the engine
   - one independently driven standby pump

   Where the output of the engine does not exceed 375 kW, the following arrangements may be accepted:
   - one main cooling water pump, which can be driven by the engine
   - one spare pump of appropriate capacity ready to be connected to the cooling circuit

b) Where, in s having more than one engine per propeller or having several propellers, each engine is served by its own cooling circuit, the second means requested in [10.3.1] is to be provided, consisting of:
   - a connection to an independently driven pump, such as a ballast pump or any other suitable sea water pump of sufficient capacity provided arrangements against overpressure in the cooling system are made. (See [10.7.4], b)),
   - or a complete spare pump identical to those serving the engines and ready to be connected to the cooling circuit.

   for pumps driven directly by the engines, a suitable set of impellers and gaskets may be accepted as prescribed by the engine Manufacturer.

   The second means of cooling is not requested for sailing yachts.

10.3.4 Individual cooling of auxiliary engines

Where each auxiliary engine is served by its own cooling circuit, no second means of cooling is required.

10.3.5 Cooling of other essential equipment

a) The second means of cooling required in [10.3.1] for essential equipment may consist of a connection to a ballast pump or other suitable sea water pump of sufficient capacity, provided arrangements are made against overpressure in the cooling system. (See [10.6.4], item b)).

b) However, where such essential equipment is duplicate, this second means may be omitted when safety justifications are provided as regards the propulsion and manoeuvring capabilities of the acht with the cooling circuit of one set of equipment disabled.

10.4 Design of fresh water cooling systems

10.4.1 General

Fresh water cooling systems are to be designed according to the applicable requirements of [10.3].

10.4.2 Cooling systems

a) Fresh water cooling systems of essential equipment are to include at least:
   - one main cooling water pump, which can be driven by the equipment
   - one independently driven standby pump.

b) The standby pump may be omitted provided an emergency connection to a suitable sea water system is fitted and arranged with a suitable change-over device. Provisions against overpressure in the cooling system are to be made in accordance with [10.6.4], item b).

c) The standby pump may also be omitted in the case of redundancy of the cooled equipment.

10.4.3 Expansion tanks

Fresh water expansion tanks are to be provided with at least:

- a de-aerating device
- a water level indicator
- a filling connection
- a drain.

10.4.4 Detection of fuel oil or lubricating oil

A device is to be fitted in fresh water cooling systems comprising fuel oil or lubricating oil heat exchangers in order to detect any contamination of the water by fuel oil or lubricating oil.

10.5 Control and monitoring

10.5.1 General

In addition to those of this item [10.5], the general requirements given in Chaptr 3 apply.

In the case of yachts with automation notations, the requirements in Part F, Chapter 2 also apply.

10.5.2 Alarms are to be provided for water cooling systems in accordance with Tab 26, in addition to the requirements stated for diesel engines in Sec 2 .

Note 1: Some departures from Tab 26 may be accepted by the Society in the case of yachts with a restricted navigation notation.

10.6 Arrangement of cooling systems

10.6.1 Sea inlets

a) At least two sea inlets complying with [2.7] are to be provided for the cooling system, one for each means of cooling required in [10.3.1].

b) The two sea inlets may be connected by a cross-over supplying both main cooling pump and standby cooling pump.

c) When the second means of cooling is a spare pump, the two sea inlets are to be provided in any event, both serving the main cooling pump.

d) The sea inlets are to be low inlets, so designed as to remain submerged under all normal navigating conditions.

   In general, one sea inlet is to be arranged on each side of the yacht .

e) One of the sea inlets may be that of the ballast pump or of the general service pump.

Table 25 : Cooling systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Sea water pump pressure or flow	L	local					
Fresh water pump pressure or flow	L	local					
Level in cooling water expansion tank	L	local					

10.6.2 Coolers

a) Coolers are to be fitted with isolating valves at the inlets and outlets.

b) Coolers external to the hull (chest coolers and keel coolers) are to be fitted with isolating valves at the shell.

10.6.3 Filters

a) Where propulsion engines and auxiliary engines for essential services are directly cooled by sea water, both in normal service and in emergency operating conditions, filters are to be fitted on the suction of cooling pumps.

b) These filters are to be so arranged that they can be cleaned without interrupting the cooling water supply.

10.6.4 Pumps

a) Cooling pumps for which the discharge pressure may exceed the design pressure of the piping system are to be fitted with relief valves in accordance with [2.4].

b) Where general service pumps, ballast pumps or other pumps may be connected to a cooling system, arrangements are to be made, in accordance with [2.4], to avoid overpressure in any part of the cooling system.

10.6.5 Air venting

Cocks are to be installed at the highest points of the pipes conveying cooling water to the water jackets for venting air or gases likely to accumulate therein. In the case of closed fresh water cooling systems, the cock is to be connected to the expansion tank.

11 Fuel oil systems

11.1 Application

11.1.1 Scope

This Article applies to all fuel oil systems supplying any kind of installation.

11.1.2 Requirements applying to fuel oil systems and not contained in this Section *(1/1/2007)*

Additional requirements are given:

- for independent fuel oil tanks, in Pt B
- for fuel oil supply equipment forming part of engines, gas turbines, and incinerators, in the corresponding sections
- for the location and scantling of tanks forming part of the ’s structure, in Pt B, Ch 1, Sec 1.

11.2 Principle

11.2.1 General *(1/1/2025)*

a) Fuel oil systems are to be so designed as to ensure the proper characteristics (purity, viscosity, pressure) of the fuel oil supply to engines.

b) Fuel oil systems are to be so designed as to prevent:
   - overflow or spillage of fuel oil from tanks, pipes, fittings, etc.
   - fuel oil from coming into contact with sources of ignition
   - overheating and seizure of fuel oil.

c) Fuel oils used for engines are to have a flashpoint complying with the provisions of Sec 1.

11.2.2 Availability of fuel systems *(1/1/2025)*

a) Fuel oil systems are to be so designed that, in the event that any one essential auxiliary of such systems becomes inoperative, the fuel oil supply to engines can be maintained (see also [11.2.1] a)). Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the yacht is not impaired.

b) Fuel oil tanks are to be so arranged that, in the event of damage to any one tank, complete loss of the fuel supply to essential services does not occur.

11.3 General

11.3.1 Arrangement of fuel oil systems

a) In a in which fuel oil is used, the arrangements for the storage, distribution and utilisation of the fuel oil are to be such as to ensure the safety of the yacht and persons on board.

b) The provisions of [5.10] are to be complied with.

11.3.2 Provision to prevent overpressure

Provisions are to be made to prevent overpressure in any oil tank or in any part of the fuel oil system. Any relief valve is to discharge to a safe position.

11.3.3 Ventilation

The ventilation of machinery spaces is to be sufficient under all normal conditions to prevent accumulation of oil vapour.

11.3.4 Access

Spaces where fuel oil is stored or handled are to be readily accessible.

11.4 Design of fuel oil filling and transfer systems

11.4.1 General

a) A system of pumps and piping for filling and transferring fuel oil is to be provided.

b) Provisions are to be made to allow the transfer of fuel oil from any storage, settling or service tank to another tank.

11.4.2 Filling systems

a) Filling pipes of fuel oil tanks are to terminate on open deck or in filling stations isolated from other spaces and efficiently ventilated. Suitable coamings and drains are to be provided to collect any leakage resulting from filling operations.

b) Arrangements are to be made to avoid overpressure in the filling lines which are served by pumps on board. Where safety valves are provided for this purpose, they are to discharge to the overflow tank referred to in [9.3.3] or to other safe positions deemed satisfactory.

11.4.3 Independence of fuel oil transfer lines

Except where permitted in [11.4.5], the fuel oil transfer piping system is to be completely separate from the other piping systems of the yacht .

11.4.4 Simultaneous transfer of fuel oil and ballast water

Where, under the provisions of [7.1.3], tanks are intended to alternately contain fuel oil and ballast water, the piping arrangement is to be such that fuel may be transferred by means of fuel pumps to or from any tank while ballast pumps are simultaneously being used.

11.4.5 Alternative carriage of fuel oil, or ballast water (1/1/2025)

Where certain compartments are likely to contain alternatively fuel oil or ballast water, the transfer pipes supplying these compartments are to be fitted with blind flanges or other appropriate change-over devices.

11.4.6 Transfer pumps

a) At least two means of transfer are to be provided. One of these means is to be a power pump. The other may consist of:
   - a standby pump,
   - or, alternatively, an emergency connection to another suitable power pump.

Note 1: Where provided, purifiers may be accepted as means of transfer.

b) Where necessary, transfer pumps are to be fitted on their discharge side with a relief valve leading back to the suction of the pump or to any other place deemed satisfactory.

11.5 Arrangement of fuel oil tanks

11.5.1 Location of fuel oil tanks

a) No fuel oil tank is to be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces.

b) As far as practicable, fuel oil tanks are to be part of the yacht's structure and are to be located outside machinery spaces of category A. Where fuel oil tanks, other than double bottom tanks, are necessarily located adjacent to or within machinery spaces of category A, at least one of their vertical sides is to be contiguous to the machinery space boundaries, and is preferably to have a common boundary with the double bottom tanks, and the area of the tank boundary common with the machinery spaces is to be kept to a minimum. Where such tanks are situated within the boundaries of machinery spaces of category A, they are not to contain fuel oil having a flashpoint of less than 60 °C.

Note 1: Machinery spaces of category A are defined in Ch 4, Sec.1.

c) The location of fuel oil tanks is to be in compliance with the requirements of Part B, Chapter 2, particularly as regards the installation of cofferdams, the separation between fuel oil tanks or bunkers and the other spaces of the , and the protection of these tanks and bunkers against any abnormal rise in temperature.

11.5.2 Use of free-standing fuel oil tanks

a) In general the use of free-standing fuel oil tanks is permitted in category A machinery spaces.

b) For the design and the installation of independent tanks, refer to Pt B, Ch 1, Sec.4.

11.6 Design of fuel oil tanks and bunkers

11.6.1 General

Tanks such as collector tanks, de-aerator tanks etc. are to be considered as fuel oil tanks for the purpose of application of this sub-article, and in particular regarding the valve requirements.

Tanks with a volume lower than 500 l will be given special consideration by the Society.

11.6.2 Scantlings

a) The scantlings of fuel oil tanks forming part of the 's structure are to comply with the requirements stated in Part B.

b) Scantlings of fuel oil tanks and bunkers which are not part of the 's structure are to comply with Pt B, Ch 1, Sec 4.

11.6.3 Filling and suction pipes

a) All suction pipes from fuel oil tanks and bunkers, including those in the double bottom, are to be provided with valves.

b) For storage tanks, filling pipes may also be used for suction purposes.

c) Where the filling pipes to fuel oil tanks are not led to the upper part of the such bunkers and tanks, they are to be provided with non-return valves at their ends, unless they are fitted with valves arranged in accordance with the requirements stated in [11.6.4].

11.6.4 Remote control of valves

a) Every fuel oil pipe which, if damaged, would allow oil to escape from a storage, settling or daily service tank having a capacity of 500 l and above situated above the double bottom, is to be fitted with a cock or valve directly on the tank capable of being closed from a safe position outside the space in which such tanks are situated in the event of a fire occurring in such space.

Note 1: For the location of the remote controls, refer to [11.10.4], item c).

b) Such valves and cocks are also to include local control and on the remote and local controls it is to be possible to verify whether they are open or shut. (See [2.6.3]).

11.6.5 Drain pipes

Where fitted, drain pipes are to be provided with self-closing valves or cocks.

A tank drain cock is not to be considered as a sampling point.

11.6.6 Air and overflow pipes

Air and overflow pipes are to comply with [9.1] and [9.3].

As far as practicable, the Service tank overflow return line to the settling tank is to be drawn from near the bottom of the service tank to the top of the settling tank to ensure any accumulating sediment in the service tank bottom is minimized.

11.6.7 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of fuel oil contained in any fuel oil tank are to be provided.

b) Sounding pipes of fuel oil tanks are to comply with the provisions of [9.2].

c) Oil-level gauges complying with [2.8.2] may be used in place of sounding pipes.

d) Gauge cocks for ascertaining the level in the tanks are not to be used.

11.7 Design of fuel oil treatment systems

11.7.1 Drains

a) Settling tanks and daily service tanks, are to be provided with drains permitting the evacuation of water and impurities likely to accumulate in the lower part of such tanks.

   If settling tanks are not provided, the fuel oil daily service tanks are to be designed and constructed in such a way as to direct water and sludge towards a drainage outlet.

b) Efficient means are to be provided for draining oily water escaping from the drains.

11.7.2 Purifiers *(1/1/2025)*

a) Where fuel oil needs to be purified, at least two purifiers are to be installed on board, each capable of efficiently purifying the amount of fuel oil necessary for the normal operation of the engines.

Note 1: On yachts with a restricted navigation notation where fuel oil needs to be purified, one purifier only may be accepted.

b) Subject to special consideration by the Society, the capacity of the standby purifier may be less than that required in a), depending on the arrangements made for the fuel oil service tanks to satisfy the requirement in [11.9.2].

c) The standby purifier may also be used for other services.

d) Each purifier is to be provided with an alarm in case of failures likely to affect the quality of the purified fuel oil.

e) The amount of water reaching the oil fuelled machinery is to be not more than 0.3% v/v or according to engine maker's recommendations.

f) Fuel treatment system performance in the removal of catfines andwater is recommended to be regularly assessed, bydrawing and analyzing samples from before and after the purifier plant and after the service tank to ensure that the catfines and water levels dot not exceedmaximum engine entry levels recommended by engine manufacturers.

g) Centrifugal separators are to be certified for a flow rating in accordance with a recognised standard, e.g. EN 17763:2022, Centrifuges - Marine fuel centrifuges - Determination of particle separation performance and certified flow rate (CFR) under defined test conditions CEN Workshop Agreement (CWA) 15375 (latest revision).

h) Centrifugal separators are to meet the safety requirements of a recognized standard, e.g. EN 12547, Centrifuges - Common safety requirements.

11.8 Fuel oil pumps

11.8.1 General

Fuel pump capacity is to ensure that fuel flow rate through the fuel system is sufficient to maintain the installed oil fuelled machinery's fuel consumption during normal operation at maximum continuous rating of the propulsion plant and normal operating load at sea of the generator plant.

Satisfactory fuel pump operation is to be verified according to the Society requirements after installation on board.

11.9 Design of fuel supply systems

11.9.1 General

a) When necessary, arrangements are to be made for cooling the marine diesel oil from engine return lines.

b) The fuel oil treatment system is to be provided with redundancy so that failure of one system will not render the other system(s) inoperative. Arrangements are to ensure that any single failure in the system will not interrupt the supply of clean fuel to machinery used for propulsion and electrical generating purposes where the fuel conditioning system is installed between fuel oil service tanks and the inlet to the combustion system.

11.9.2 Fuel oil service tanks

a) Two fuel oil service tanks for each type of fuel used on board necessary for propulsion and vital systems, or equivalent arrangements, are to be provided on each new , with a capacity of at least 8 h at maximum continuous rating of the propulsion plant and normal operating load at sea of the generator plant.

11.9.3 Fuel oil supply to internal combustion engines *(1/1/2025)*

a) The suctions of engine fuel pumps are to be arranged at an appropriate distance above the fuel-oil treatment tank drain point in order to prevent accumulated water and sludge being drawn into the fuel oil treatment system (e.g. 5% of the tank volume is below the suction pipe).

b) Suitable filters are to be provided on the fuel oil line to the injection pumps.

Fuel filters are to reduce the level of contaminants (i.e.metallic particles / sediments etc.) in the fuel to a level commensurate with the downstream equipment manufacturers' requirements.

Internal combustion engines intended for main propulsion are to be fitted with at least two filters, or similar devices, so arranged that one of the filters can be overhauled while the other is in use.

Note 1: Where the propulsion plant consists of:

- two or more engines, each one with its own filter, or
- one engine with an output not exceeding 375 kW,

the second filter may be replaced by a readily accessible and easily replaceable spare filter.

c) Oil filters fitted in parallel are to be so arranged as to minimise the possibility of a filter under pressure being opened by mistake.

Filter chambers are to be provided with suitable means for:

- ventilating when put into operation
- de-pressurising before being opened.

Valves or cocks used for this purpose are to be fitted with drain pipes led to a safe location.

d) Oil filters are to be so located that in the event of a leakage the fuel oil cannot be pulverised onto the exhaust manifold.

e) When a fuel oil booster pump is fitted which is essential to the operation of the main engine, a standby pump, connected ready for immediate use, is to be provided.

The standby pump may be replaced by a complete spare pump of appropriate capacity ready to be connected, in the following cases:

- where two or more main engines are fitted, each with its own booster pump
- in yachts having main engines each with an output not exceeding 375 kW.

f) Excess fuel oil from pumps or injectors is to be led back to the service or settling tanks, or to other tanks intended for this purpose.

g) De-aeration tanks fitted in pressurised fuel oil return lines are to be equipped with at least:

- an automatic venting valve or equivalent device discharging to the daily service tank
- a non-return valve in the return line from the engines.

h) Components of a diesel engine fuel system are to be designed considering the maximum peak pressure which will be experienced in service, including any high pressure pulses which are generated and transmitted back into the fuel supply and spill lines by the action of fuel injection pumps.

i) Connections within the fuel supply and spill lines are to be constructed having regard to their ability to prevent pressurised fuel oil leaks while in service and after maintenance.

j) In multi-engine installations which are supplied from the same fuel source, means of isolating the fuel supply and spill piping to individual engines, are to be provided. The means of isolation are not to affect the operation of the other engines and are to be operable from a position not rendered inaccessible by a fire on any of the engines.

k) For high pressure fuel oil pipes, refer to Sec 2.

11.9.4 Sampling points

The fuel oil supply system is to be provided with sampling points.

The sampling points are to be:

- easily and safely accessible
- downstream of the in-use fuel oil service tank
- as close to the fuel oil combustion machinery as safely feasible taking into account the type of fuel oil, flow-rate, temperature, and pressure behind the selected sampling point
- clearly marked for easy identification and described in either the piping diagram or other relevant documents
- located in a position shielded from any heated surface or electrical equipment and the shielding device or construction should be sturdy enough to endure leaks, splashes or spray under design pressure of the fuel oil supply line so as to preclude impingement of fuel oil onto such surface or equipment

- provided with suitable drainage to the drain tank or other safe location
- equipped with closable valve and permanent means of closure like plugs.

A tank drain cock is not to be considered as a sampling point.

11.10 Control and monitoring

11.10.1 General

In addition to those of this item [11.10], the general requirements given in Chapter 3 apply.

In the case of yachts with automation notations, the requirements in Part F, Chapter 2 also apply.

11.10.2 Monitoring

Alarms and safeguards are to be provided for fuel oil systems in accordance with Tab 27.

Note 1: Some departures from Tab 27 may be accepted by the Society in the case of yachts with a restricted navigation notation.

Table 26 : Fuel oil systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Fuel oil overflow tank level	H **(1)**						
Air pipe water trap level on fuel oil tanks	H **(2)**						
Sludge tank level		local					
Fuel oil settling tank and service tank temperature		local					
Fuel oil level in daily service tank	L+H **(1)**	local					
Fuel oil daily service tank temperature		local					
(1) Or sightglasses on the overflow pipe **(2)** Or alternative arrangement as per [9.1.7] item c)							

11.10.3 Automatic controls

Automatic temperature control is to be provided for:

- steam heaters or heaters using other media
- electric heaters.

11.10.4 Remote controls

a) The remote control arrangement of valves fitted on fuel oil tanks is to comply with [11.6.4].

b) The power supply to:
   - fuel oil burning pumps,
   - transfer pumps and other pumps of the fuel oil system,
   - and fuel oil purifiers,

   is to be capable of being stopped from a position within the space containing the pumps and from another position located outside such space and always accessible in the event of fire within the space.

c) Remote control of the valve fitted to the emergency generator fuel tank is to be in a separate location from that of other valves fitted to tanks in the engine room.

d) The positions of the remote controls are also to comply with Chapter 3.

11.11 Construction of fuel oil piping systems

11.11.1 Materials

a) Fuel oil pipes and their valves are to be of steel or other approved material, except that the use of flexible pipes may be accepted provided they comply with [2.5.2].

b) Where the Society may permit the conveying of oil and combustible liquids through accommodation and service spaces, the pipes conveying oil or combustible liquids are to be of a material approved by the Society having regard to the fire risk.

c) For valves fitted to fuel oil tanks and which are under a static pressure head, steel or nodular cast iron may be accepted. However, ordinary cast iron valves may be used in fuel piping systems where the design pressure is lower than 0,7 MPa and the design temperature is below 60°C.

d) Internal galvanisation of fuel oil pipes and tank is to be avoided.

11.11.2 Pipe thickness

The thickness of pipes containing fuel oil is to be calculated for a design pressure according to Tab 28.

Table 27 : Definition of the design pressure for fuel oil systems

Working temperature ® Working pressure ¯	T <= 60°C	T > 60°C
P £ 0,7 MPa	0,3 MPa or maximum working pressure, whichever is the greater	0,3 MPa or maximum working pressure, whichever is the greater
P > 0,7 MPa	maximum working pressure	1,4 MPa or maximum working pressure, whichever is the greater

11.11.3 Pipe connections

a) Connections and fittings of pipes containing fuel oil are to be suitable for a design pressure according to Tab 28.

b) Connections of pipes conveying heated fuel oil are to be made by means of close-fitting flanges, with joints made of a material impervious to oil heated to 160°C and as thin as possible.

11.12 Arrangement of fuel oil piping systems

11.12.1 Passage of fuel oil pipes through tanks

a) Fuel pipes are not to pass through tanks containing fresh water or other flammable oil, unless they are contained within tunnels.

b) Transfer pipes passing through ballast tanks are to comply with [5.2.3].

11.12.2 Passage of pipes through fuel oil tanks

Fresh water pipes are not to pass through fuel oil tanks, unless such pipes are contained within tunnels.

11.12.3 Drains on fuel oil piping

Where fitted, drain pipes on fuel oil piping are to be provided with self-closing valves or cocks.

12 Lubricating oil systems

12.1 Application

12.1.1 This Article applies to lubricating oil systems serving diesel engines, turbines, reverse and reduction gears, for lubrication or control purposes.

It also applies to separate oil systems intended for the cooling of engine pistons.

12.2 Principle

12.2.1 General

a) Lubricating oil systems are to be so designed as to ensure reliable lubrication of the engines, turbines and other equipment, including electric motors, intended for propulsion:
   - over the whole speed range, including starting, stopping and, where applicable, manoeuvring
   - for all the inclinations angles stated in Sec 1

b) Lubricating oil systems are to be so designed as to ensure sufficient heat transfer and appropriate filtration of the oil.

c) Lubricating oil systems are to be so designed as to prevent oil from entering into contact with sources of ignition.

12.2.2 Availability

a) Lubricating oil systems are to be so designed that, in the event that any one pump is inoperative, the lubrication of the engines and other equipment is maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the yacht is not impaired.

b) An emergency lubricating system, such as a gravity system, is to be provided to ensure sufficient lubrication of equipment which may be damaged due to a failure of the pump supply.

12.3 General

12.3.1 Arrangement of lubricating oil systems

a) The arrangements for the storage, distribution and utilisation of oil used in pressure lubrication systems are to be such as to ensure the safety of the yacht and persons on board.

b) The provisions of [5.10] are to be complied with, where applicable.

12.3.2 Filtration

a) In forced lubrication systems, a device is to be fitted which efficiently filters the lubricating oil in the circuit.

b) The filters provided for this purpose for main machinery and machinery driving electric propulsion generators are to be so arranged that they can be easily cleaned without stopping the lubrication of the machines.

c) The fineness of the filter mesh is to comply with the requirements of the engine or turbine manufacturers.

d) Where filters are fitted on the discharge side of lubricating oil pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

12.3.3 Purification

Where provided, lubricating oil purifiers are to comply with [11.7.3].

12.4 Design of engine lubricating oil systems

12.4.1 Lubrication of propulsion engines

a) Main engines are to be provided with at least two power lubricating pumps, of such a capacity as to maintain normal lubrication with any one pump out of action.

b) In the case of propulsion plants comprising:
   - more than one engine, each with its own lubricating pump, one of the pumps mentioned in a) may be a spare pump, provided the arrangements are such as to enable the to proceed at a full load speed of not less than 7 knots when one of the engines is out of service, or
   - one engine with an output not exceeding 375 kW, one of the pumps mentioned in a) may be a spare pump ready to be connected to the lubricating oil system, provided disassembling and reassembling operations can be carried out on board in a short time.

12.4.2 Lubrication of auxiliary engines

a) For auxiliary engines with their own lubricating pump, no additional pump is required.

b) For auxiliary engines with a common lubricating system, at least two pumps are to be provided. However, when such engines are intended for non-essential services, no additional pump is required.

12.5 Design of lubricating oil tanks

12.5.1 Remote control of valves

Lubricating oil tanks with a capacity of 500 litres and above are to be fitted with remote controlled valves in accordance with the provisions of [11.6.4]. Where it is determined that the unintended operation of a quick closing valve on the oil lubricating tank would endanger the safe operation of the main propulsion and essential auxiliary machinery remote controlled valves need not be installed.

Suction valves from storage tanks need not be arranged with remote controls provided they are kept closed except during transfer operations.

12.5.2 Filling and suction pipes

Filling and suction pipes are to comply with the provisions of [11.6.3].

12.5.3 Air and overflow pipes

Air and overflow pipes are to comply with the provisions of [9.1] and [9.3].

12.5.4 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of lubricating oil contained in the tanks are to be provided.

b) Sounding pipes are to comply with the provisions of [9.2].

c) Oil-level gauges complying with [2.8.2] may be used in place of sounding pipes.

d) Gauge cocks for ascertaining the level in the tanks are not to be used.

12.5.5 Oil collecting tanks for engines

a) In s required to be fitted with a double bottom, wells for lubricating oil under main engines may be permitted by the Society provided it is satisfied that the arrangements give protection equivalent to that afforded by a double bottom.

b) Where, in s required to be fitted with a double bottom, oil collecting tanks extend to the outer bottom, a valve is to be fitted on the oil drain pipe, located between the engine sump and the oil drain tank. This valve is to be capable of being closed from a readily accessible position located above the working platform.

Alternative arrangements will be given special consideration.

c) Oil collecting pipes from the engine sump to the oil collecting tank are to be submerged at their outlet ends.

12.6 Control and monitoring

12.6.1 General

In addition to those of this item [12.6], the general requirements given in Chapter 3 apply.

In the case of yachts with automation notations, the requirements in Part F, Chapter 2 also apply.

12.6.2 Monitoring

In addition to the requirements in Sec 2 for diesel engines, in Sec 4 for gas turbines and in Sec 6 for gears, alarms are to be provided for lubricating oil systems in accordance with Tab 29.

Note 1: Some departures from Tab 29 may be accepted by the Society in the case of yachts with a restricted navigation notation.

12.7 Construction of lubricating oil piping systems

12.7.1 Materials

Materials used for oil piping system in machinery spaces are to comply with the provisions of [11.11.1].

12.7.2 Sight-flow glasses

The use of sight-flow glasses in lubricating systems is permitted, provided that they are shown by testing to have a suitable degree of fire resistance.

Table 28 : Lubricating oil systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Air pipe water trap level of lubricating oil tank **(1)**	H						
Sludge tank level		local					
(1) See [9.1.7]							

13 Hydraulic systems

13.1 Application

13.1.1 Hydraulic installations intended for essential services

Unless otherwise specified, this Article applies to all hydraulic power installations intended for essential services, including:

- actuating systems of thrusters
- actuating systems of steering gear

- actuating systems of lifting appliances
- manoeuvring systems of hatch covers
- manoeuvring systems of stern, bow and side doors
- manoeuvring systems of mobile ramps, movable platforms, elevators and telescopic wheelhouses
- starting systems of diesel engines and gas turbines
- remote control of valves.

13.1.2 Hydraulic installations located in spaces containing sources of ignition

Hydraulic power installations not serving essential services but located in spaces where sources of ignition are present are to comply with the provisions of [13.3.2], [143.3.3], [13.4.3] and [13.4.4].

13.1.3 Low pressure or low power hydraulic installations

Hydraulic power installations with a design pressure of less than 2,5 MPa and hydraulic power packs of less than 5 kW will be given special consideration by the Society.

13.1.4 Very high pressure hydraulic installations

Hydraulic power installations with a design pressure exceeding 35 MPa will be given special consideration by the Society.

13.2 Principle

13.2.1 General

Hydraulic systems are to be so designed as to:

- avoid any overload of the system
- maintain the actuated equipment in the requested position (or the driven equipment at the requested speed)
- avoid overheating of the hydraulic oil
- prevent hydraulic oil from coming into contact with sources of ignition.

13.2.2 Availability

a) Hydraulic systems are to be so designed that, in the event that any one essential component becomes inoperative, the hydraulic power supply to essential services can be maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the yacht is not impaired. Such reduction of capability is not acceptable for steering gear.

b) When a hydraulic power system is simultaneously serving one essential system and other systems, it is to be ensured that:
   - any operation of such other systems, or
   - any failure in the whole installation external to the essential system

   does not affect the operation of the essential system.

c) Provision b) applies in particular to steering gear.

d) Hydraulic systems serving lifting or hoisting appliances, including platforms, ramps, hatch covers, lifts, etc., are to be so designed that a single failure of any component of the system may not result in a sudden undue displacement of the load or in any other situation detrimental to the safety of the yacht and persons on board.

13.3 General

13.3.1 Definitions

a) A power unit is the assembly formed by the hydraulic pump and its driving motor.

b) An actuator is a component which directly converts hydraulic pressure into mechanical action.

13.3.2 Limitations of use of hydraulic oils

a) Oils used for hydraulic power installations are to have a flashpoint not lower than 150°C and be suitable for the entire service temperature range.

b) The hydraulic oil is to be replaced in accordance with the specification of the installation manufacturer.

13.3.3 Location of hydraulic power units

a) Whenever practicable, hydraulic power units are to be located outside main engine rooms.

b) Where this requirement is not complied with, shields or similar devices are to be provided around the units in order to avoid an accidental oil spray or mist on heated surfaces which may ignite oil.

13.4 Design of hydraulic systems

13.4.1 Power units

a) Hydraulic power installations are to include at least two power units so designed that the services supplied by the hydraulic power installation can operate simultaneously with one power unit out of service. A reduction of the performance not affecting the safety of the yacht may be accepted.

b) Low power hydraulic installations not supplying essential services may be fitted with a single power unit, provided that alternative means, such as a hand pump, are available on board.

c) For steering gear see Sec.11.

13.4.2 Filtering equipment

a) A device is to be fitted which efficiently filters the hydraulic oil in the circuit.

b) Where filters are fitted on the discharge side of hydraulic pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

13.4.3 Provision for cooling

Where necessary, appropriate cooling devices are to be provided.

13.4.4 Provision against overpressure

a) Safety valves of sufficient capacity are to be provided at the high pressure side of the installation.

b) Safety valves are to discharge to the low pressure side of the installation or to the service tank.

13.4.5 Provision for venting

Cocks are to be provided in suitable positions to vent the air from the circuit.

13.5 Design of hydraulic tanks and other components

13.5.1 Hydraulic oil service tanks

a) Service tanks intended for hydraulic power installations supplying essential services are to be provided with at least:
   - a level gauge complying with [2.9.2]
   - a temperature indicator
   - a level switch complying with [13.6.3]. The level switch may be omitted in the case of hydraulic systems capable of being operated only in local position.

b) The free volume in the service tank is to be at least 10% of the tank capacity.

13.5.2 Hydraulic oil storage tanks

a) Hydraulic power installations supplying essential services are to include a storage tank of sufficient capacity to refill the whole installation should the need arise case of necessity.

b) For hydraulic power installations of less than 5 kW, the storage means may consist of sealed drums or tins stored in satisfactory conditions.

13.5.3 Hydraulic accumulators

The hydraulic side of the accumulators which can be isolated is to be provided with a relief valve or another device offering equivalent protection in case of overpressure.

13.6 Control and monitoring

13.6.1 General

In addition to those of this item [13.6], the general requirements given in Chapter 3 apply.

In the case of s with automation notations, the requirements in Part F, Chapter 2 also apply.

13.6.2 Indicators

Arrangements are to be made for connecting a pressure gauge where necessary in the piping system.

13.6.3 Monitoring

Alarms and safeguards for hydraulic power installations intended for essential services, except steering gear, for which the provisions of Sec 11 apply, are to be provided in accordance with Tab 30.

Note 1: Some departures from Tab 30 may be accepted by the Society in the case of yachts with a restricted navigation notation.

Note 2: Tab 30 does not apply to steering gear.

13.7 Construction of hydraulic oil piping systems

13.7.1 Materials

a) Pipes are to be made of seamless steel. The use of welded steel pipes will be given special consideration by the Society.

b) Casings of pumps, valves and fittings are to be made of steel or other ductile material.

Table 29 : Hydraulic oil systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Pump pressure	L						
Service tank level	L **(1)**						
(1) The low level alarm is to be activated before the quantity of lost oil reaches 100 litres or 50 % of the circuit volume , whichever is the less.							

14 Compressed air systems

14.1 Application

14.1.1 This Article applies to compressed air systems intended for essential services, and in particular to:

- starting of engines,
- control and monitoring.

14.2 Principle

14.2.1 General

a) Compressed air systems are to be so designed that the compressed air delivered to the consumers:
   - is free from oil and water,
   - does not have an excessive temperature.

b) Compressed air systems are to be so designed as to prevent overpressure in any part of the systems.

14.2.2 Availability

a) Compressed air systems are to be so designed that, in the event of failure of one air compressor or one air receiver intended for starting, control purposes or other essential services, the air supply to such services can be maintained.

b) The compressed air system for starting main engines and auxiliary engines for essential services is to be so arranged that it is possible to ensure the initial charge of air receiver(s) without the aid of a power source outside the yacht.

14.3 Design of starting air systems

14.3.1 Initial charge of starting air receivers

a) Where, for the purpose of [14.2.2], an emergency air compressor is fitted, its driving engine is to be capable of being started by hand-operated devices. Independent electrical starting batteries may also be accepted.

b) A hand compressor may be used for the purpose of [14.2.2] only if it is capable of charging within one hour an air receiver of sufficient capacity to provide 3 consecutive starts of a propulsion engine or of an engine capable of supplying the energy required for operating one of the main compressors.

14.3.2 Number and capacity of air compressors

a) Where main and auxiliary engines are arranged for starting by compressed air, two or more air compressors are to be fitted with a total capacity sufficient to supply within one hour, the receivers being at atmospheric pressure, the quantity of air needed to satisfy the provisions of Sec 2, [5.1.1]. This capacity is to be approximately equally divided between the number of compressors fitted, excluding the emergency compressor fitted in pursuance of [14.3.1].

b) At least one of the compressors is to be independent of the engines for which starting air is supplied and is to have a capacity of not less than 50% of the total required in a).

14.3.3 Number and capacity of air receivers

a) Where main engines are arranged for starting by compressed air, at least two air receivers are to be fitted of approximately equal capacity and capable of being used independently.

b) The total capacity of air receivers is to be sufficient to provide without replenishment the number of starts required in Sec 2, [5.1.1]. It is also to take into account the air delivery to other consumers, such as control systems, whistle, etc., which are connected to the air receivers.

14.3.4 Air supply for starting the emergency generating set

Starting air systems serving main or auxiliary engines may be used for starting the emergency generator under the conditions specified in Sec 2, [5.1.3].

14.4 Design of control and monitoring air systems

14.4.1 Air supply

a) The control and monitoring air supply to essential services is to be available from two sources of a sufficient capacity to allow normal operation with one source out of service.

b) At least one air vessel fitted with a non-return valve is to be provided for control and monitoring purposes.

c) Pressure reduction units used in control and monitoring air systems intended for essential services are to be duplicated, unless an alternative air supply is provided.

d) Failure of the control air supply is not to cause any sudden change of the controlled equipment which may be detrimental to the safety of the yacht.

14.4.2 Pressure control

Arrangements are to be made to maintain the air pressure at a suitable value in order to ensure satisfactory operation of the installation.

14.4.3 Air treatment

In addition to the provisions of [14.8.3], arrangements are to be made to ensure cooling, filtering and drying of the air prior to its introduction in the monitoring and control circuits.

14.5 Design of air compressors

14.5.1 Prevention of excessive temperature of discharged air

Air compressors are to be so designed that the temperature of discharged air cannot exceed 95°C. For this purpose, the air compressors are to provided where necessary with:

- suitable cooling means
- fusible plugs or alarm devices set at a temperature not exceeding 120°.

14.5.2 Prevention of overpressure

a) Air compressors are to be fitted with a relief valve complying with [2.5.3].

b) Means are to be provided to prevent overpressure wherever water jackets or casings of air compressors may be subjected to dangerous overpressure due to leakage from air pressure parts.

c) Water space casings of intermediate coolers of air compressors are to be protected against any overpressure which might occur in the event of rupture of air cooler tubes.

14.5.3 Crankcase relief valves

Air compressors having a crankcase volume of at least 0,6 m^3 are to be fitted with crankcases explosion relief valves satisfying the provisions of Sec 2, [4.3.4].

14.5.4 Provision for draining

Air compressors are to be fitted with a drain valve.

14.6 Control and monitoring of compressed air systems

14.6.1 General

In addition to those of this item [17.6], the general requirements given in Chapter 3 apply.

In the case of yachts with automation notations, the requirements in Part F, Chapter 2 also apply.

14.6.2 Monitoring

Alarms and safeguards are to be provided for compressed air systems in accordance with Tab 31.

Note 1: Some departures from Tab 31 may be accepted by the Society in the case of yachts with a restricted navigation notation.

14.6.3 Automatic controls

Automatic pressure control is to be provided for maintaining the air pressure in the air receivers within the required limits.

14.7 Materials

14.7.1 Pipes and valve bodies in control and monitoring air systems and in other air systems intended for non-essential services may be made of plastic in accordance with the provisions of App 3.

14.8 Arrangement of compressed air piping systems

14.8.1 Prevention of overpressure

Means are to be provided to prevent overpressure in any part of compressed air systems. Suitable pressure relief arrangements are to be provided for all systems.

14.8.2 Air supply to compressors

a) Provisions are to be made to reduce to a minimum the entry of oil into air pressure systems.
b) Air compressors are to be located in spaces provided with sufficient ventilation.

14.8.3 Air treatment and draining

a) Provisions are be made to drain air pressure systems.
b) Efficient oil and water separators, or filters, are to be provided on the discharge of compressors, and drains are to be installed on compressed air pipes wherever deemed necessary.

14.8.4 Lines between compressors, receivers and engines

All discharge pipes from starting air compressors are to be lead directly to the starting air receivers, and all starting air pipes from the air receivers to main or auxiliary engines are to be entirely separate from the compressor discharge pipe system.

14.8.5 Protective devices for starting air mains

Non-return valves and other safety devices are to be provided on the starting air mains of each engine in accordance with the provisions of Sec 2, [5.1.1].

15 Exhaust gas systems

15.1 General

15.1.1 Application *(1/1/2025)*

This Article applies to:

- exhaust gas pipes from engines and gas turbines
- smoke ducts from incinerators.

15.1.2 Principle

Exhaust gas systems are to be so designed as to:

- limit the risk of fire
- prevent gases from entering manned spaces
- prevent water from entering engines.

15.2 Design of exhaust systems

15.2.1 General

Exhaust systems are to be so arranged as to minimise the intake of exhaust gases into manned spaces, air conditioning systems and engine intakes. The exhaust piping is to be fitted in a manner such as to ensure an adequate air gap from the adjacent hull structure and other fittings; such air gap is to be, in general, not less than 200 mm.

iSee also Part B Ch.1 Sec.1 [5.3.3]

15.2.2 Limitation of exhaust line surface temperature

a) Exhaust gas pipes and silencers are to be either water cooled or efficiently insulated where:
   - their surface temperature may exceed 220°C, or
   - they pass through spaces of the where a temperature rise may be dangerous.

b) The insulation of exhaust systems is to comply with the provisions of Sec 1, [3.7.1].

15.2.3 Limitation of pressure losses (1/1/2025)

Exhaust gas systems are to be so designed that pressure losses in the exhaust lines do not exceed the maximum values permitted by the engine manufacturers.

Table 30 : Compressed air systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Compressor lubricating oil pressure (except where splash lubrication)	L						
Air pressure after reducing valves	L+H	local					
Starting air pressure before main shut-off valve	L	local + R **(1)**					
Air vessel pressure	L+H						
(1) Remote indication is required if starting of air compressor are remote controlled, from wheelhouse for example							

15.2.4 Intercommunication of engine exhaust gas lines *(1/1/2025)*

a) Exhaust gas from different engines is not to be led to a common exhaust main, exhaust gas economiser, unless each exhaust pipe is provided with a suitable isolating device.

15.2.5 Exhaust gas pipe terminations

a) Where exhaust pipes are led overboard close to the load waterline, means are to be provided to prevent water from entering the engine or the .

b) Where exhaust pipes are water cooled, they are to be so arranged as to be self-draining overboard.

15.2.6 Control and monitoring

A high temperature alarm is to be provided in the exhaust gas manifolds of thermal oil heaters to detect any outbreak of fire.

15.3 Materials

15.3.1 General

Materials of exhaust gas pipes and fittings are to be resistant to exhaust gases and suitable for the maximum temperature expected.

15.3.2 Use of plastics

The use of non-metallic materials may be accepted in water cooled systems in accordance with the provisions of App 3.

15.4 Arrangement of exhaust piping systems

15.4.1 Provision for thermal expansion

a) Exhaust pipes and smoke ducts are to be so designed that any expansion or contraction does not cause abnormal stresses in the piping system, and in particular in the connection with engine turboblowers.

b) The devices used for supporting the pipes are to allow their expansion or contraction.

15.4.2 Provision for draining *(1/1/2025)*

a) Drains are to be provided where necessary in exhaust systems in order to prevent water flowing into the engine.

b) Where exhaust pipes are water cooled, they are to be so arranged as to be self-draining overboard.

15.4.3 Flexible hoses

The use of flexible hoses in water cooled exhaust systems will be given special consideration by the Society.

15.4.4 Silencers

Engine silencers are to be so arranged as to provide easy access for cleaning and overhaul.

15.5 Exhaust gas treatment systems

15.5.1

When exhaust gas treatment systems are installed, they are to be in compliance with the requirements in [16].

16 Exhaust gas treatment systems

16.1 Application

16.1.1

This Article applies to selective catalytic reduction (SCR) systems.

16.2 Exhaust ducting

16.2.1

The parts of the Exhaust gas treatment systems containing exhaust gas are to be in compliance with [15].

When the exhaust gas treatment system may influence the operation of essential machinery, arrangements are to be made to ensure the continuity of the service concerned also in case of possible failures of the exhaust gas treatment system (e.g. exhaust gas bypasses are to be arranged, to enable continued operation of engine intended to drive single essential users in case of filters clogging by particulate matter).

16.3 Materials

16.3.1

Materials used for equipment and piping systems are to be suitable with fluids conveyed, taking into account their chemical reactivity.

Aluminium and galvanized pipes are to be avoided for equipment and piping systems in contact with fluids containing sodium hydroxide or acids.

Copper is to be avoided for equipment and piping systems in contact with fluids containing ammonia.

16.4 Use of reductants in SCR systems

16.4.1 Use of aqueous ammonia (28% or less concentration of ammonia)

Aqueous ammonia is not to be used as a reductant in a SCR except where it can be demonstrated that it is not practicable to use a urea based reductant.

Where an application is made to use aqueous ammonia as the reductant then the arrangements for its loading, carriage and use are to be derived from a risk based analysis.

16.4.2 Use of anydrous ammonia (99.5% or greater concentration of ammonia by weight)

Anydrous ammonia is not to be used as a reductant in a SCR except where it can be demonstrated that it is not practicable to use a urea based reductant and where the Flag Administration agrees to its use.

Where it is not practicable to use a urea reductant then it is also to be demonstrated that it is not practicable to use aqueous ammonia.

Where an application is made to use anhydrous ammonia as the reductant then the arrangements for its loading, carriage and use are to be derived from a risk based analysis.

16.4.3 Use of urea based ammonia (e.g. 40%/60% urea/water solution)

The requirements for SCR reductants tanks with volume below of 500 L will be considered by the Society on a case by case basis.

Where urea based ammonia (e.g. AUS 40 - aqueous urea solution specified in ISO 18611-1:2014) is used, the storage tank is to be arranged so that any leakage will be contained and prevented from making contact with heated surfaces. All pipes or other tank penetrations are to be provided with manual closing valves attached to the tank. Tank and piping arrangements are to be approved.

The storage tank may be located within the engine room.

The storage tank is to be protected from excessively high or low temperatures applicable to the particular concentration of the solution. Depending on the operational area of the , this may necessitate the fitting of heating and/or cooling systems. The physical conditions recommended by applicable recognized standards (such as ISO 18611-3:2014) are to be taken into account to ensure that the contents of the aqueous urea tank are maintained to avoid any impairment of the urea solution during storage.

If a urea storage tank is installed in a closed compartment, the area is to be served by an effective mechanical ventilation system of extraction type providing not less than 6 air changes per hour which is independent from the ventilation system of accommodation, service spaces, or control stations. The ventilation system is to be capable of being controlled from outside the compartment. A warning notice requiring the use of such ventilation before entering the compartment shall be provided outside the compartment adjacent to each point of entry. These requirements also apply to closed compartments normally entered by persons:

- when they are adjacent to the urea integral tanks and there are possible leak points (e.g. manhole, fittings) from these tanks; or
- when the urea piping systems pass through these compartments, unless the piping system is made of steel or other equivalent material with melting point above 925 degrees C and with fully welded joints.

Alternatively, where a urea storage tank is located within an engine room a separate ventilation system is not required when the general ventilation system for the space is arranged so as to provide an effective movement of air in the vicinity of the storage tank and is to be maintained in operation continuously except when the storage tank is empty and has been thoroughly ventilated.

Each urea storage tank is to be provided with temperature and level monitoring arrangements. High and low level alarms together with high and low temperature alarms are also to be provided.

Where urea based ammonia solution is stored in integral tanks, the following are to be considered during the design and construction:

- These tanks may be designed and constructed as integral part of the hull, (e.g. double bottom, wing tanks).
- These tanks are to be coated with appropriate anti-corrosion coating and cannot be located adjacent to any fuel oil and fresh water tank.
- These tanks are to be designed and constructed as per the structural requirements applicable to hull and primary support members for a deep tank construction.
- These tanks are to be included in the 's stability calculation.

The reductant piping and venting systems are to be independent of other service piping and/or systems. Reductant piping systems are not to be located in accommodation, service spaces, or control stations. The vent pipes of the storage tank are to terminate in a safe location on the weather deck and the tank venting system is to be arranged to prevent entrance of water into the urea tank.

Reductant tanks are to be of steel or other equivalent material with a melting point above 925 degrees C.

Note 1:

Material requirement “to be of steel or other equivalent material” with a melting point above 925 degrees C is not applicable for integral tanks on FRP yachts, provided that the integral tanks are coated and/or insulated with a self-extinguishing material.

Pipes/piping systems are to be of steel or other equivalent material with melting point above 925 degrees C, except downstream of the tank valve, provided this valve is metal seated and arranged as fail-to-closed or with quick closing from a safe position outside the space in the event of fire; in such case, type approved plastic piping may be accepted even if it has not passed a fire endurance test. Reductant tanks and pipes/piping systems are to be made with a material compatible with reductant or coated with appropriate anti-corrosion coating.

For the protection of crew members, the is to have on board suitable personnel protective equipment. Eyewash are to be provided, the location and number of these eyewash stations and safety showers are to be derived from the detailed installation arrangements.

Urea storage tanks are to be arranged so that they can be emptied of urea and ventilated by means of portable or permanent systems.

17 Certification, inspection and testing of piping systems

17.1 Application

17.1.1 This Article defines the certification and workshop inspection and testing programme to be performed on:

- the various components of piping systems,
- the materials used for their manufacture.

On board testing is dealt with in Sec 16.

17.1.2 In this Section are define the certification and workshop inspection and testing program to be performed on piping systems to be fitted on board of yachts when required in accordance with the relevant Table of Pt A Ch 2 App 3.

17.2 Type tests

17.2.1 Type tests of flexible hoses and expansion joints

a) Type approval tests are to be carried out on flexible hoses or expansion joints of each type and of sizes to be agreed with the Society, in accordance with Tab 32 (see also the Tasneef "Rules for the type approval of flexible hoses and expansion joints").

b) The flexible hoses or expansion joints subjected to the tests are to be fitted with their connections.

Table 31 : Type tests to be performed for flexible hoses and expansion joints

Test	Flexible hoses and expansion joints in non-metallic material	Flexible hoses and expansion joints in metallic material
bursting test	X	X
fire-resistance test	X **(1)**	NR
vibration test **(2)**	X	X
pressure impulse test	X **(6)**	NR
flexibility test	X **(3)**	NR
elastic deformation test	NR	X
cyclic expansion test **(4)**	NR	X

Test	Flexible hoses and expansion joints in non-metallic material	Flexible hoses and expansion joints in metallic material
resistance of the material **(5)**	X	X

(1) only for flexible hoses and expansion joints used in flammable oil systems and, when required, in sea water systems.
(2) the Society reserves the right to require the vibration test in case of installation of the components on sources of high vibrations.
(3) only for flexible hoses conveying low temperature fluids.
(4) the Society reserves the right to require the cyclic expansion test for piping systems subjected to expansion cycles
(5) internal to the conveyed fluid to be demonstrated by suitable documentation and / or tests.
(6) only for flexible hoses.
Note 1: X = required, NR = not required.

17.2.2 Type tests of air pipe closing devices

Type approval tests are to be carried out on each type and size of air pipe closing device, in accordance with Tab 33 and the "Rules for type approval and testing of air pipe closing devices".

Table 32 : Type tests to be performed for air pipe closing appliances

Test to be performed	Type of air closing appliance	
	Float type	Other types
tightness test **(1)**	X	X
flow characteristic determination **(2)**	X	X
impact test of floats	X	
pressure loading test of floats	X **(3)**	

(1) the tightness test is to be carried out during immerging/emerging in water, in the normal position and at an inclination of 40 degrees.
(2) pressure drop is to be measured versus flow rate using water.
(3) only for non-metallic floats.
Note 1: X = required

17.3 Testing of materials

17.3.1 General

a) Detailed specifications for material tests are given in Part D.

b) Requirements for the inspection of welded joints are given in Part D.

17.3.2 Tests for materials

a) Where required in Tab 34, materials used for pipes, valves and other accessories are to be subjected to the following tests:
   - tensile test at ambient temperature
   - flattening test or bend test, as applicable
   - impact test as prescribed in the relevant section of Part D
   - tensile test at the design temperature, except if one of the following conditions is met:
     - the design temperature is below 200°C
     - the mechanical properties of the material at high temperature have been approved
     - the scantling of the pipes is based on reduced values of the permissible stress.

b) Plastic materials are to be subjected to the tests specified in App 3.

17.4 Hydrostatic testing of piping systems and their components

17.4.1 General

Pneumatic tests are to be avoided wherever possible. Where such testing is absolutely necessary in lieu of the hydraulic pressure test, the relevant procedure is to be submitted to the Society for acceptance prior to testing.

17.4.2 Hydrostatic pressure tests of piping

a) Hydrostatic pressure tests are to be carried out to the Surveyor's satisfaction for:
- all class I and II pipes and their integral fittings
- all steam pipes, feed water pipes, compressed air pipes, and fuel oil and other flammable oil pipes with a design pressure greater than 0,35 MPa and their associated integral fittings.

b) These tests are to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

Note 1: Classes of pipes are defined in [1.5.2].

c) Pressure testing of small bore pipes (less than 15 mm) may be waived at the discretion of the Surveyor, depending on the application.

d) Where the design temperature does not exceed 300°C, the test pressure is to be equal to 1,5 p.

e) Where the design temperature exceeds 300°C, the test pressure is to be as follows:
- for carbon and carbon-manganese steel pipes, the test pressure is to be equal to 2 p
- for alloy steel pipes, the test pressure P_H is to be determined by the following formula, but need not exceed 2 p:

$$p_H = 1,5\frac{K_{100}}{K_T}p$$

where:

K_{100} : permissible stress for 100°C, as stated in Tab 10

K_T : permissible stress for the design temperature, as stated in Tab 10.

Note 2: Where alloy steels not included in Tab 10 are used, the permissible stresses will be given special consideration.

Where it is necessary to avoid excessive stress in way of bends, branches, etc., the Society may give special consideration to the reduction of the test pressure to a value not less than 1,5 p. The membrane stress is in no case to exceed 90% of the yield stress at the testing temperature.

f) While satisfying the condition stated in b), the test pressure of pipes located on the discharge side of centrifugal pumps driven by steam turbines is not to be less than the maximum pressure liable to be developed by such pumps with closed discharge at the operating speed of their overspeed device.

g) When the hydrostatic test of piping is carried out on board, these tests may be carried out in conjunction with the tests required in [17.4.7]

17.4.3 Hydrostatic tests of valves, fittings and heat exchangers

a) Valves and fittings non-integral with the piping system and intended for class I and II pipes are to be subjected to hydrostatic tests in accordance with standards recognised by the Society, at a pressure not less than 1,5 times the design pressure p defined in [1.3.2].

b) Valves intended to be fitted on the side below the load waterline are to be subjected to hydrostatic tests under a pressure not less than 0,5 MPa.

c) The shells of appliances such as heaters, coolers and heat exchangers which may be considered as pressure vessels are to be tested under the conditions specified in Sec 5.

d) The nests of tubes or coils of heaters, coolers and heat exchangers are to be submitted to a hydraulic test under the same pressure as the fluid lines they serve.

e) For coolers of internal combustion engines, see Sec 2.

17.4.4 Hydrostatic tests of fuel oil tanks not forming part of the yacht's structure

Reference to be made to Pt B Ch 1 Sec.4.

17.4.5 Hydrostatic tests of pumps and compressors

a) Cylinders, covers and casings of pumps and compressors are to be subjected to a hydrostatic test under a pressure at least equal to the pressure p_H determined by the following formulae:
- $p_H = 1,5\ p$ where $p \leq 4$
- $p_H = 1,4\ p + 0,4$ where $4 < p \leq 25$
- $p_H = p + 10,4$ where $p > 25$

where
- p_H : test pressure, in MPa
- p : design pressure, as defined in [1.3.2], in MPa.

p_H is not to be less than 0,4 MPa.

b) Intermediate coolers of compressors are to undergo a hydrostatic test under a pressure at least equal to the pressure p_H defined in a). When determining p_H, the pressure p to be considered is that which may result from accidental communication between the cooler and the adjoining stage of higher pressure, allowance being made for any safety device fitted on the cooler.

c) The test pressure for water spaces of compressors and their intermediate coolers is not to be less than 1,5 times the design pressure in the space concerned, subject to a minimum of 0,2 MPa.

d) For air compressors and pumps driven by diesel engines, see Sec 2.

17.4.6 Hydrostatic test of flexible hoses and expansion joints

a) Each flexible hose or expansion joint, together with its connections, is to undergo a hydrostatic test under a pressure at least equal to 1,5 times the maximum service pressure.

b) During the test, the flexible hose or expansion joint is to be repeatedly deformed from its geometrical axis.

17.4.7 Pressure tests of piping after assembly on board

After assembly on board, the following tightness tests are to be carried out in the presence of the Surveyor.

In general, all the piping systems covered by these requirements are to be checked for leakage under operational conditions and, if necessary, using special techniques other than hydrostatic testing. In particular, heating coils in tanks and liquid or gas fuel lines are to be tested to not less than 1,5 times the design pressure but in no case less than 0,4 MPa.

17.5 Testing of piping system components during manufacturing

17.5.1 Pumps

a) Bilge and fire pumps are to undergo a performance test.

17.5.2 Centrifugal separators

Centrifugal separators used for fuel oil and lubricating oil are to undergo a running test, normally with a fuel water mixture.

Each separator is to be tested to ensure that it is capable to prepare fuel with an amount of water not exceeding 0,3% v/v.

17.6 Inspection and testing of piping systems

17.6.1 The inspections and tests required for piping systems and their components are summarised in Tab 34.

Table 33 : Inspection and testing at works for piping systems and their components (1/1/2025)

No.	Item	Tests for materials **(1)**		Inspections and tests for the product **(1)**			Reference to the Rules
		Tests required	Type of material certificate **(2)**	During manufacturing (NDT)	After completion **(3)**	Type of product certificate **(2)**	
1	Valves, pipes and fittings a) class I, d ≥ 50 mm or class II, d ≥ 100 mm b) class I, d < 50 mm or class II, d < 100 mm c) class III where "d" is the nominal diameter	 X X X	 C W W	 X **(4)** X **(4)**	 X X X	 C C W	 [17.3.2] [3.6.2] [3.6.3] [17.4.3]; Pt D, Ch 2, Sec 2, [1.8] [17.3.2] [3.6.2] [3.6.3] [17.4.3]; Pt D, Ch 2, Sec 2, [1.8] [17.3.2]
2	Flexible hoses and expansion joints	X **(5)**	W		X	C	[17.3.2] [17.4.6]
3	Pumps and compressors a) all b) bilge and fire pumps	 X X	 W W		 X X	 C C	 [17.4.5] [17.5.1]
4	Centrifugal separators				X	C	[17.5.2]
5	Prefabricated pipe lines a) class I b) class II c) class III			 X **(4) (6)** X **(4) (7)**	 X X X	 C C W **(8)**	 [3.6.2] [3.6.3] [17.4.2] [3.6.2] [3.6.3] [17.4.2] [.4.2]

(1) X = test is required
(2) C = class certificate
W = works' certificate
(3) Visual examination and hydrostatic pressure test as required.
(4) NDT on welding in case of welded construction.
(5) If metallic.
(6) 100% radiographic examination or equivalent on butt-welded joints of pipes with an external diameter exceeding 75 mm. Magnetic particle or liquid penetrant tests on other types of welded joints.
(7) 10% radiographic examination or equivalent on butt-welded joints of pipes with an external diameter exceeding 100 mm. Magnetic particle or liquid penetrant tests on other types of welded joints.
(8) C certificate for the piping systems mentioned in [17.4.2] a).

17.6.2 For valves and through hull fittings intended to be arranged on the side of yachts if the nominal diameter is more than 80 mm, a class certificate is to be required. For diameter equal or less than 80 mm, Tasneef type approval may be accepted.

17.7 Type approved piping system components

17.7.1 Issue of Tasneef Type Approval Certificate

The piping system components to which this Section is applicable when accepted in Pt A, Ch 2, App 3 may be type approved by The Society.

For a particular type of piping system component, a Tasneef Type Approval Certificate valid for 3 years can be obtained

by the Manufacturer by testing a prototype according to the requirements contained in [17].

The validity of the certificate in the course of the 3 years is subject to satisfactory results of shop trials witnessed by a Tasneef Surveyor; the periodicity and procedures are to be agreed with Tasneef on a case-by-case basis.

During the period of the Certificate's validity, and for the next of the same type, the tests required by the Rules can be carried out by the Manufacturer, who will issue a Certificate of conformity to the prototype.

17.7.2 Renewal of Tasneef Type Approval Certificate

For the renewal of the Tasneef Type Approval Certificate, the tests to be carried out will be specified in a scheme to be agreed with The Society.

SECTION 11 STEERING

1 General

1.1 Application

1.1.1 Scope

Unless otherwise specified, the requirements of this Section apply to the steering gear systems of all mechanically propelled s, and to the steering mechanism of thrusters used as means of propulsion.

1.1.2 Cross references

In addition to the those provided in this Section, steering gear systems are also to comply with the requirements of:

- Sec 16, as regards sea trials
- Pt B, Ch 1, Sec 6, as regards the rudder and the rudder stock

1.2 Documentation to be submitted

1.2.1 Documents to be submitted for all steering gear

Before starting construction, all plans and specifications listed in Tab 1 are to be submitted to the Society for approval.

Table 1 : Documents to be submitted for steering gear

No.	I / A **(2)**	Document **(1)**
1	I	Assembly drawing of the steering gear including sliding blocks, guides, stops and other similar components
2	I	General description of the installation and of its functioning principle
3	I	Operating manuals of the steering gear and of its main components
4	I	Description of the operational modes intended for steering in normal and emergency conditions
5	A	For hydraulic steering gear, the schematic layout of the hydraulic piping of power actuating systems, including the hydraulic fluid refilling system, with indication of: • the design pressure • the maximum working pressure expected in service • the diameter, thickness, material specification and connection details of the pipes • the hydraulic fluid tank capacity • the flashpoint of the hydraulic fluid
6	I	For hydraulic pumps of power units, the assembly longitudinal and transverse sectional drawings and the characteristic curves (3)
7	A	Assembly drawings of the rudder actuators and constructional drawings of their components, with, for hydraulic actuators, indication of: • the design torque • the maximum working pressure • the relief valve setting pressure
8	I	Constructional drawings of the relief valves for protection of the hydraulic actuators, with indication of: • the setting pressure • the relieving capacity (3)
9	A	Diagrams of the electric power circuits
10	A	Functional diagram of control, monitoring and safety systems including the remote control from the navigating bridge, with indication of the location of control, monitoring and safety devices
11	A	Constructional drawings of the strength parts providing a mechanical transmission of forces to the rudder stock (tiller, quadrant, connecting rods and other similar items), with the calculation notes of the shrink-fit connections

No.	I / A **(2)**	Document **(1)**
12	I/A	For azimuth thrusters used as steering means, the specification and drawings of the steering mechanism and, where applicable, documents 2 to 6 and 8 to 11 above
(1) Constructional drawings are to be accompanied by the specification of the materials employed and, where applicable, by the welding details and welding procedures. **(2)** A = to be submitted for approval I = to be submitted for information. (3) For yachts of more than 10000 GT		

1.2.2 Additional documents

The following additional documents are to be submitted:

- analysis in relation to the risk of single failure, where required in this Section
- analysis in relation to the risk of hydraulic locking, where required in this Section
- failure analysis in relation to the availability of the hydraulic power supply, where required

1.3 Definitions

1.3.1 Main steering gear

Main steering gear is the machinery, rudder actuators, steering gear power units, if any, and 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 yacht under normal service conditions.

1.3.2 Steering gear power unit

Steering gear power unit is:

- in the case of electric steering gear, an electric motor and its associated electrical equipment
- in the case of electrohydraulic steering gear, an electric motor and its associated electrical equipment and connected pump
- in the case of other hydraulic steering gear, a driving engine and connected pump.

1.3.3 Auxiliary steering gear

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the yacht in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose.

1.3.4 Power actuating system

Power actuating system is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear 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 and rudder stock, or components serving the same purpose.

1.3.5 Rudder actuator

Rudder actuator is the component which directly converts hydraulic pressure into mechanical action to move the rudder.

1.3.6 Electro- mechanic actuator

Rudder actuator is the component which directly converts electrical power into mechanical action to move the rudder..

1.3.7 Steering gear control system

Steering gear control system is the equipment by which orders are transmitted from the navigation bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

Steering gear control system is also understood to cover “the equipment required to control the steering gear power actuating system”.

1.3.8 Maximum ahead service speed

Maximum ahead service speed is the greatest speed which the yacht is designed to maintain in service at sea at the deepest seagoing draught.

1.3.9 Maximum astern speed

Maximum astern speed is the speed which it is estimated the yacht can attain at the designed maximum astern power at the deepest seagoing draught.

1.3.10 Maximum working pressure

Maximum working pressure is the maximum expected pressure in the system when the steering gear is operated to comply with the provisions of [2.1.2], item b).

1.3.11 Hydraulic locking

Hydraulic locking means all situations where two hydraulic systems (usually identical) oppose each other in such a way that it may lead to loss of steering. It can either be caused by pressure in the two hydraulic systems working against each other or by hydraulic “by-pass” meaning that the systems puncture each other and cause pressure drop on both sides or make it impossible to build up pressure.

1.4 Symbols

1.4.1 The following symbols are used for strength criteria of steering gear components:

V : Maximum service speed, in knots, with the yacht on summer load waterline. When the speed is less than 10 knots, V is to be replaced by the value (V+20)/3

d_s : Rule diameter of the rudder stock in way of the tiller, in mm, as defined in Pt B, Ch 10, Sec 1

d_{se} : Actual diameter of the upper part of the rudder stock in way of the tiller, in mm
(in the case of a tapered coupling, this diameter is measured at the base of the assembly)

T_R : Rule design torque of the rudder stock given, in kN.m, by the following formula:

$$T_R = 13{,}5 \cdot d_s^3 \cdot 10^{-6}$$

T_E : For hand emergency operation, design torque due to forces induced by the rudder, in kN.m, given by the following formula:

$$T_E = 0{,}62 \cdot \left(\frac{V_E + 2}{V + 2}\right)^2 \cdot T_R$$

where:

- $V_E = 7$, where $V \leq 14$
- $V_E = 0{,}5\,V$, where $V > 14$

T_G : For main hydraulic or electrohydraulic steering gear, torque induced by the main steering gear on the rudder stock when the pressure is equal to the setting pressure of the relief valves protecting the rudder actuators

Note 1: for hand-operated main steering gear, the following value is to be used:

$T_G = 1{,}25.T_R$

T_A : For auxiliary hydraulic or electrohydraulic steering geas, torque induced by the auxiliary steering gear on the rudder stock when the pressure is equal to the setting pressure of the relief valves protecting the rudder actuators

Note 2: for hand-operated auxiliary steering gear, the following value is to be used:

$T_A = 1{,}25.T_E$

T'_G : For steering gear which can activate the rudder with a reduced number of actuators, the value of T_G in such conditions

σ : Normal stress due to the bending moments and the tensile and compressive forces, in N/mm²

τ : Tangential stress due to the torsional moment and the shear forces, in N/mm²

σ_a : Permissible stress, in N/mm²

σ_c : Combined stress, determined by the following formula:

$$\sigma_c = \sqrt{\sigma^2 + 3\tau^2}$$

R : Value of the minimum specified tensile strength of the material at ambient temperature, in N/mm²

R_e : Value of the minimum specified yield strength of the material at ambient temperature, in N/mm²

R'_e : Design yield strength, in N/mm², determined by the following formulae:

- $R'_e = R_e$, where $R \geq 1{,}4\,R_e$
- $R'_e = 0{,}417\,(R_e + R)$ where $R < 1{,}4\,R_e$

2 Design and construction -

2.1 Strength, performance and power operation of the steering gear

2.1.1 Main steering gear

The main steering gear and rudder stock shall be:

a) of adequate strength and capable of steering the at maximum ahead service speed which shall be demonstrated,

b) capable of putting the rudder over from 35° on one side to 35° on the other side with the yacht at its deepest seagoing draught and running ahead at maximum ahead service speed and, under the same conditions, from 35° on either side to 30° on the other side in not more than 28s; where it is impractical to demonstrate compliance with this requirement during sea trials with the Yacht at its deepest seagoing draught and running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch, s regardless of date of construction may demonstrate compliance with this requirement by one of the following methods:

   1) during sea trials the yacht is at even keel and the rudder fully submerged whilst running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch; or

   2) where full rudder immersion during sea trials cannot be achieved, an appropriate ahead speed shall be calculated using the submerged rudder blade area in the proposed sea trial loading condition. The calculated ahead speed shall result in a force and torque applied to the main steering gear which is at least as great as if it was being tested with the yacht at its deepest seagoing draught and running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch; or

   3) the rudder force and torque at the sea trial loading condition have been reliably predicted and extrapolated to the full load condition. The speed of the yacht shall correspond to the number of maximum continuous revolutions of the main engine and maximum design pitch of the propeller;

c) operated by power where necessary to meet the requirements of b) and in any case when the Society requires a rudder stock of over 120 mm diameter in way of the tiller, excluding strengthening for navigation in ice, and

d) so designed that they will not be damaged at maximum astern speed; however, this design requirement need not be proved by trials at maximum astern speed and maximum rudder angle.

2.1.2 Auxiliary steering gear

The auxiliary steering gear and rudder stock shall be:

a) of adequate strength and capable of steering the yacht at navigable speed and of being brought speedily into action in an emergency,

b) capable of putting the rudder over from 15° on one side to 15° on the other side in not more than 60s with the yacht at its deepest seagoing draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater; where it is impractical to demonstrate compliance with this requirement during sea trials with the at its deepest seagoing draught and running ahead at one half of the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch or 7 knots, whichever is greater, s regardless of date of construction, including those constructed before 1 January 2009, may demonstrate compliance with this requirement by one of the following methods:

   1) during sea trials the yacht is at even keel and the rudder fully submerged whilst running ahead at one half of the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch or 7 knots, whichever is greater; or

   2) where full rudder immersion during sea trials cannot be achieved, an appropriate ahead speed shall be calculated using the submerged rudder blade area in the proposed sea trial loading condition. The calculated ahead speed shall result in a force and torque applied to the auxiliary steering gear which is at least as great as if it was being tested with the yacht at its deepest seagoing draught and running ahead at one half of the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch or 7 knots, whichever is greater; or

   3) the rudder force and torque at the sea trial loading condition have been reliably predicted and extrapolated to the full load condition; and

c) operated by power where necessary to meet the requirements of b) and in any case when the Society requires a rudder stock of over 230 mm diameter in way of the tiller, excluding strengthening for navigation in ice.

2.2 Control of the steering gear

2.2.1 Main and auxiliary steering gear control

Steering gear control shall be provided:

a) for the main steering gear, both on the navigation bridge and:
   in the steering gear compartment, or
   at the local steering control position

b) where the main steering gear is arranged in accordance with [2.3], by two independent control systems, both operable from the navigation bridge and the steering gear compartment. This does not require duplication of the steering wheel or steering lever. Where the control system consists in a hydraulic telemotor, a second independent system need not be fitted,

c) for the auxiliary steering gear, in the steering gear compartment and, if power operated, it shall also be operable from the navigation bridge and to be independent of the control system for the main steering gear.

2.2.2 Control systems operable from the navigating bridge

Any main and auxiliary steering gear control system operable from the navigating bridge shall comply with the following:

- if electrical, it shall be served by its own separate circuit supplied from a steering gear power circuit from a point within the steering gear compartment, or directly from switchboard busbars supplying that steering gear power circuit at a point on the switchboard adjacent to the supply to the steering gear power circuit,
- means shall be provided in the steering gear compartment for disconnecting any control system operable from the navigation bridge from the steering gear it serves,
- the system shall be capable of being brought into operation from a position on the navigating bridge,
- in the event of failure of electrical power supply to the control system, an audible and visual alarm shall be given on the navigation bridge, and
- short-circuit protection only shall be provided for steering gear control supply circuits.

2.3 Availability

2.3.1 Arrangement of main and auxiliary steering gear

The main steering gear and the auxiliary steering gear shall be so arranged that the failure of one will not render the other inoperative.

2.3.2 Omission of the auxiliary steering gear

Where the main steering gear comprises two or more identical power units, auxiliary steering gear need not be fitted, provided that the main steering gear is capable of operating the rudder:

a) as required in [2.1.2], item b), while operating with all power units,

b) as required in [2.1.3], item b), while any one of the power units is out of operation,

The main steering gear is to be so arranged that, after a single failure in its piping system or in one of the power units, the defect can be isolated so that steering capability can be maintained or speedily regained.

The Society may accept the fitting of steering gear of proven service reliability even where it does not comply with the requirements laid down here as far as the hydraulic system is concerned.

On yachts fitted with multiple rudders or thrusters, where at least two of the rudders or thrusters are similar and fitted with an actuating system independent of each other, the independent actuating systems may be regarded as a main and an auxiliary steering gear, and therefore the actuating system of either is not required to be duplicated provided that:

- such independent actuation systems are also fitted with independent power supplies and control systems, and
all are operable from the navigation bridge,

- means are available to move to, and lock in a neutral position any rudder or thruster in an emergency. (except for thrusters not pro-ducing significant hydrodynamic steering forces in the absence of propulsion power),

- satisfactory course keeping and maneuverability of the yacht with one rudder or thruster out of service is
demonstrated at sea trials at one half of the maximum ahead service speed or 7 knots, whichever is the greater,
and at maneuvering speed ahead and astern.

Steering gear other than of the hydraulic type is to achieve standards equivalent to the requirements of this paragraph to the satisfaction of the Society.

2.3.3 Hydraulic power supply

The hydraulic system intended for main and auxiliary steering gear is to be independent of all other hydraulic systems of the yacht.

2.3.4 Non-duplicated components

Special consideration is to be given to the suitability of any essential component which is not duplicated.

2.3.5 Hydraulic locking

Where the steering gear is so arranged that more than one system (either power or control) can be simultaneously operated, the risk of hydraulic locking caused by single failure is to be considered.

2.4 Mechanical Components

2.4.1 General

a) All steering gear components and the rudder stock are to be of sound and reliable construction to the satisfaction of the Society.

b) Any non-duplicated essential component is, where appropriate, to utilise anti-friction bearings, such as ball bearings, roller bearings or sleeve bearings, which are to be permanently lubricated or provided with lubrication fittings.

c) The construction is to be such as to minimise local concentration of stress.

d) All steering gear components transmitting mechanical forces to the rudder stock, which are not protected against overload by structural rudder stops or mechanical buffers, are to have a strength at least equivalent to that of the rudder stock in way of the tiller.

2.4.2 Materials and welds

a) All steering gear components transmitting mechanical forces to the rudder stock (such as tillers, quadrants, or similar components) are to be of steel or other approved ductile material complying with the requirements of Part D. In general, such material is to have an elongation of not less than 12% and a tensile strength not greater than 650 N/mm^2.

b) The use of grey cast iron is not permitted, except for redundant parts with low stress level, subject to special consideration by the Society. It is not permitted for cylinders.

c) The welding details and welding procedures are to be submitted for approval.

d) All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads are to be full penetration type or of equivalent strength.

2.4.3 Scantling of components

The scantling of steering gear components is to be determined considering the design torque M_T and the permissible value σ_a of the combined stress, as given in:

- Tab 2 for components which are protected against overloads induced by the rudder
- Tab 3 for components which are not protected against overloads induced by the rudder.

Table 2 : Scantling of components protected against overloads induced by the rudder

Conditions of use of the components	M_T	σ_a
Normal operation	T_G	• if $T_G \leq 1,25\ T_R$: $\sigma_a = 1,25\ \sigma_0$ • if $1,25\ T_R < T_G < 1,50\ T_R$: $\sigma_a = \sigma_0\ T_G/T_R$ • if $T_G \geq 1,50\ T_R$: $\sigma_a = 1,50\ \sigma_0$ where $\sigma_0 = 0,55\ R'_e$
Normal operation, with a reduced number of actuators	T'_G	• if $T'_G \leq 1,25\ T_R$: $\sigma_a = 1,25\ \sigma_0$ • if $1,25\ T_R < T'_G < 1,50\ T_R$: $\sigma_a = \sigma_0\ T_G/T_R$ • if $T'_G \geq 1,50\ T_R$: $\sigma_a = 1,50\ \sigma_0$ where $\sigma_0 = 0,55\ R'_e$

Conditions of use of the components	M_T	σ_a
Emergency operation achieved by hydraulic or electrohydraulic steering gear	lower of T_R and 0,8 T_A	0,69 R'_e
Emergency operation, with a reduced number of actuators	lower of T_R and 0,8 T'_G	0,69 R'_e
Emergency operation achieved by hand	T_E	0,69 R'_e

Table 3 : Scantling of components not protected against overloads induced by the rudder

Conditions of use of the components	M_T	σ_a
Normal operation	T_R	0,55 R'_e
Normal operation, with a reduced number of actuators	lower of T_R and 0,8 T'_G	0,55 R'_e
Emergency operation achieved by hydraulic or electrohydraulic steering gear	lower of T_R and 0,8 T_A	0,69 R'_e
Emergency operation, with a reduced number of actuators	lower of T_R and 0,8 T'_G	0,69 R'_e
Emergency operation achieved by hand	T_E	0,69 R'_e

2.4.4 Tillers, quadrants and rotors

a) The scantling of the tiller is to be determined as follows:

- the depth H_0 of the boss is not to be less than d_s
- the radial thickness of the boss in way of the tiller is not to be less than $0,4.d_s$
- the section modulus of the tiller arm in way of the end fixed to the boss is not to be less than the value Z_b, in cm^3, calculated from the following formula:

  $$Z_b = \frac{0,147 \cdot d_s^3}{1000} \cdot \frac{L'}{L} \cdot \frac{R_e}{R'_e}$$

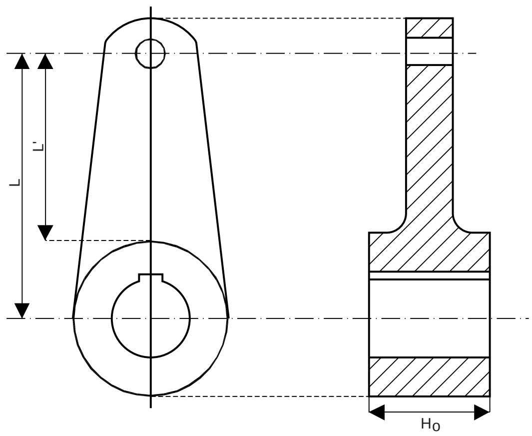
  where:

  L : Distance from the centreline of the rudder stock to the point of application of the load on the tiller (see Fig 1)

  L' : Distance between the point of application of the above load and the root section of the tiller arm under consideration (see Fig 1)

- the width and thickness of the tiller arm in way of the point of application of the load are not to be less than one half of those required by the above formula
- in the case of double arm tillers, the section modulus of each arm is not to be less than one half of the section modulus required by the above formula.

Figure 1 : Tiller arm



b) The scantling of the quadrants is to be determined as specified in a) for the tillers. When quadrants having two or three arms are provided, the section modulus of each arm is not to be less than one half or one third, respectively, of the section modulus required for the tiller.

Arms of loose quadrants not keyed to the rudder stock may be of reduced dimensions to the satisfaction of the Society, and the depth of the boss may be reduced by 10 per cent.

c) Keys are to satisfy the following provisions:

- the key is to be made of steel with a yield stress not less than that of the rudder stock and that of the tiller boss or rotor without being less than 235 N/mm^2
- the width of the key is not to be less than 0,25.d_s
- the thickness of the key is not to be less than 0,10.d_s
- the ends of the keyways in the rudder stock and in the tiller (or rotor) are to be rounded and the keyway root fillets are to be provided with small radii of not less than 5 per cent of the key thickness.

d) Bolted tillers and quadrants are to satisfy the following provisions:

- the diameter of the bolts is not to be less than the value d_b, in mm, calculated from the following formula:

$$= 153\sqrt{\frac{T_R}{n(b + 0,5d_{se})}} \cdot \frac{23}{R}$$

where:

n : Number of bolts located on the same side in respect of the stock axis (n is not to be less than 2)

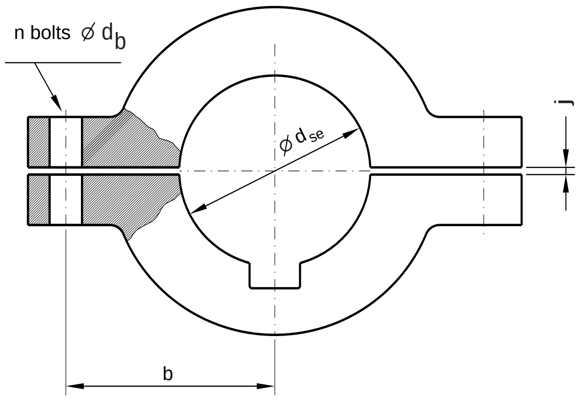
b : Distance between bolts and stock axis, in mm (see Fig 2)

R_{eb} : Yield stress, in N/mm^2, of the bolt material

- the thickness of the coupling flanges is not to be less than the diameter of the bolts
- in order to ensure the efficient tightening of the coupling around the stock, the two parts of the tiller are to bored together with a shim having a thickness not less than the value j, in mm, calculated from the following formula:

$$= 0,0015 \cdot d$$

Figure 2 : Bolted tillers



e) Shrink-fit connections of tiller (or rotor) to stock are to satisfy the following provisions:

- the safety factor against slippage is not to be less than:
  - 1 for keyed connections
  - 2 for keyless connections
- the friction coefficient is to be taken equal to:
  - 0,15 for steel and 0,13 for spheroidal graphite cast iron, in the case of hydraulic fit
  - 0,17 in the case of dry shrink fitting
- the combined stress according to the von Mises criterion, due to the maximum pressure induced by the shrink fitting and calculated in way of the most stressed points of the shrunk parts, is not to exceed 80 per cent of the yield stress of the material considered

Note 1: Alternative stress values based on FEM calculations may also be considered by the Society.

- the entrance edge of the tiller bore and that of the rudder stock cone are to be rounded or bevelled.

2.4.5 Piston rods

The scantling of the piston rod is to be determined taking into account the bending moments, if any, in addition to compressive or traction forces and is to satisfy the following provisions:

a) $\sigma_c \leq \sigma_a$

where:

σ_c : Combined stress as per [1.4.1]

σ_a : Permissible stress as per [2.1.3]

b) in respect of the buckling strength:

$$\frac{4}{D_2^2} \cdot \left(\omega F_c + \frac{8M}{D_2}\right) \leq 0{,}9c$$

where:

D_2 : Piston rod diameter, in mm

F_c : Compression force in the rod, in N, when it extends to its maximum stroke

M : Possible bending moment in the piston rod, in N.mm, in way of the fore end of the cylinder rod bearing

ω : $= \alpha + (\beta^2 - \alpha)^{0,5}$

with:

$\alpha = 0{,}0072\ (l_s/d_s)^2 . R'_e/235$,

$\beta = 0{,}48 + 0{,}5\ \alpha + 0{,}1\ \alpha^{0,5}$,

l_s = Length, in mm, of the maximum unsupported reach of the cylinder rod.

2.4.6 Equivalent rudder stock diameter

Where the rudders are served by a common actuating system, the diameter of the rudder stock referred to in [2.1.2], item c) and in [2.1.3] item c) is to be replaced by the equivalent diameter d obtained from the following formula:

$$d = \sqrt[3]{\sum_j d_j^3}$$

with:

d_j : Rule diameter of the upper part of the rudder stock of each rudder in way of the tiller, excluding strengthening for navigation in ice.

2.4.7 Synchronisation for yachts with multiple rudders

A system for synchronising the movement of the rudders is to be fitted, either:

- by a mechanical coupling, or
- by other systems giving automatic synchronising adjustment.

Where the synchronisation of the rudder motion is not achieved by a mechanical coupling, the following provisions are to be met:

- the angular position of each rudder is to be indicated on the navigation bridge, or
- the rudder angle indicators are to be independent from each other and, in particular, from the synchronising system
- in case of failure of the synchronising system, means are to be provided for disconnecting this system so that steering capability can be maintained or rapidly regained.

2.5 Hydraulic system

2.5.1 General

a) The design pressure for calculations to determine the scantlings of piping and other steering gear components subjected to internal hydraulic pressure shall be at least 1,25 times the maximum working pressure to be expected under the operational conditions specified in [2.1] , taking into account any pressure which may exist in the low pressure side of the system.

At the discretion of the Society, high cycle and cumulative fatigue analysis may be required for the design of piping and components, taking into account pulsating pressures due to dynamic loads.

b) The power piping for hydraulic steering gear is to be arranged so that transfer between units can be readily effected.

c) Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

The hydraulic piping system, including joints, valves, flanges and other fittings, is to comply with the requirements of Sec 10 for class I piping systems, and in particular with the requirements of Sec 10, [13], unless otherwise stated.

2.5.2 Materials

a) Ram cylinders, pressure housings of rotary vane type actuators, hydraulic power piping, valves, flanges and fittings are to be of steel or other approved ductile material.

b) In general, such material is to have an elongation of not less than 12% and a tensile strength not greater than 650 N/mm^2.

Grey cast iron may be accepted for valve bodies and redundant parts with low stress level, excluding cylinders, subject to special consideration.

2.5.3 Isolating valves

Shut-off valves, non-return valves or other appropriate devices are to be provided:

- to comply with the availability requirements of [2.3].
- to keep the rudder steady in position in case of emergency.

In particular, for all yachts with non-duplicated actuators, isolating valves are to be fitted at the connection of pipes to the actuator, and are to be directly fitted on the actuator.

2.5.4 Flexible hoses

a) Flexible hoses may be installed between two points where flexibility is required but are not to be subjected to torsional deflexion (twisting) under normal operation. In general, the hose is to be limited to the length necessary to provide for flexibility and for proper operation of machinery.

b) Hoses are to be high pressure hydraulic hoses according to recognised standards and suitable for the fluids, pressures, temperatures and ambient conditions in question.

c) They are to be of a type approved by the Society according to Sec 10, [2.6].

2.5.5 Relief valves

a) Relief valves shall be fitted to any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source or from external forces. The setting of the relief valves shall not exceed the design pressure. The valves shall be of adequate size and so arranged as to avoid an undue rise in pressure above the design pressure.

b) The setting pressure of the relief valves is not to be less than 1,25 times the maximum working pressure.

c) The minimum discharge capacity of the relief valve(s) is not to be less than the total capacity of the pumps which can deliver through it (them), increased by 10%. Under such conditions, the rise in pressure is not to exceed 10% of the setting pressure. In this respect, due consideration is to be given to the foreseen extreme ambient conditions in relation to oil viscosity.

2.5.6 Hydraulic oil reservoirs

Hydraulic power-operated steering gear shall be provided with the following:

- a low level alarm for each hydraulic fluid reservoir to give the earliest practicable indication of hydraulic fluid leakage. Audible and visual alarms shall be given on the navigation bridge and in the machinery space where they can be readily observed (for yachts intended for operation with unattended machinery spaces the alarm is to be provided at a suitable main machinery control position).
- a fixed storage tank having sufficient capacity to recharge at least one power actuating system including the reservoir, where the main steering gear is required to be power operated. The storage tank shall be permanently connected by piping in such a manner that the hydraulic systems can be readily recharged from a position within the steering gear compartment and shall be provided with a contents gauge.

2.5.7 Hydraulic pumps

a) Hydraulic pumps are to be type tested in accordance with the provisions of [5.1.1].

b) Special care is to be given to the alignment of the pump and the driving motor.

2.5.8 Filters

a) Hydraulic power-operated steering gear shall be provided with arrangements to maintain the cleanliness of the hydraulic fluid taking into consideration the type and design of the hydraulic system.

b) Filters of appropriate mesh fineness are to be provided in the piping system, in particular to ensure the protection of the pumps.

2.5.9 Accumulators

Accumulators, if fitted, are to be designed in accordance with Sec 10, [13.5.3].

2.5.10 Rudder actuators

a) Rudder actuators, are to be designed in accordance with the relevant requirements of Sec 5 for class I pressure vessels also considering the following provisions.

b) The permissible primary general membrane stress is not to exceed the lower of the following values:

$$\frac{R}{A} \quad \text{or} \quad \frac{R_e}{B}$$

where A and B are given in Tab 4.

c) Oil seals between non-moving parts, forming part of the external pressure boundary, are to be of the metal upon metal or equivalent type.

d) Oil seals between moving parts, forming part of the external pressure boundary, are to be duplicated, so that the failure of one seal does not render the actuator inoperative. Alternative arrangements providing equivalent protection against leakage may be accepted.

e) The strength and connection of the cylinder heads (or, in the case of actuators of the rotary type, the fixed vanes) acting as rudder stops are to comply with the provisions of [4.3.1].

Table 4 : Value of coefficients A and B

Coefficient	Steel	Cast steel	Nodular cast iron
A	3,5	4	5
B	1,7	2	3

2.6 Electrical systems

2.6.1 General design

The electrical systems of the main steering gear and the auxiliary steering gear are to be so arranged that the failure of one will not render the other inoperative.

2.6.2 Power circuit supply

a) Electric or electrohydraulic steering gear comprising one or more power units is to be served by at least two exclusive circuits fed directly from the main switchboard; however, one of the circuits may be supplied through the emergency switchboard.

b) Auxiliary electric or electrohydraulic steering gear, associated with main electric or electrohydraulic steering gear, may be connected to one of the circuits supplying the main steering gear.

c) The circuits supplying electric or electrohydraulic steering gear are to have adequate rating for supplying all motors which can be simultaneously connected to them and may be required to operate simultaneously.

d) When, yacht in a of less than 1600 tons gross tonnage, auxiliary steering gear which is required by [2.1.3], item c) to be operated by power is not electrically powered or is powered by an electric motor primarily intended for other services, the main steering gear may be fed by one circuit from the main switchboard.

e) Where the rudder stock is required to be over 230 millimetres in diameter in way of the tiller, excluding strengthening for naviga-tion in ice, an alternative power supply either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment is to be provided, sufficient at least to supply the steering gear power unit such that the latter is able to perform the duties of auxiliary steering gear.This power source is to be activated automatically, within 45 seconds, in the event of failure of the main source(s) of electrical power.The independent source is to be used only for this purpose.The alternative power source is also to supply the steering gear control system, the remote control of the power unit and the rudder angle indicator.The alternative power source is to have a capacity for at least 10 minutes of continuous operation.

f) An electric or electrohydraulic auxiliary steering gears associated with a main steering gear is to be served by a circuit fed di-rectly from the emergency switchboard, if available, or from an independent power source having capacity for at least 5 minutes of continuous operation. The alternative power source is also to supply the steering gear control system, the re-mote control of the power unit and the rudder angle indicator.

2.6.3 Motors and associated control gear

a) To determine the required characteristics of the electric motors for power units, the breakaway torque and maximum working torque of the steering gear under all operating conditions are to be considered. The ratio of pull-out torque to rated torque is to be at least 1,6.

b) Motors for steering gear power units may be rated for intermittent power demand.

The rating is to be determined on the basis of the steering gear characteristics of the yacht in question; the rating is always to be at least:

- S3 - 40% for motors of electric steering gear power units
- S6 - 25% for motors of electrohydraulic steering gear power units and for convertors.

c) Each electric motor of a main or auxiliary steering gear power unit is to be provided with its own separate motor starter gear, located within the steering gear compartment.

2.6.4 Supply of motor control circuits and steering gear control systems

a) Each control for starting and stopping of motors for power units is to be served by its own control circuits supplied from its respective power circuits.

b) Any electrical main and auxiliary steering gear control system operable from the navigating bridge is to be served by its own separate circuit supplied from a steering gear power circuit from a point within the steering gear compartment, or directly from switchboard busbars supplying that steering gear power circuit at a point on the switchboard adjacent to the supply to the steering gear power circuit. The power supply systems are to be protected selectively.

c) The remote control of the power unit and the steering gear control systems is to be supplied also by the alternative power source when required by [2.6.2], item e).

2.6.5 Circuit protection

a) Short-circuit protection is to be provided for each control circuit and each power circuit of electric or electrohydraulic main and auxiliary steering gear.

b) No protection other than short-circuit protection is to be provided for steering gear control system supply circuits.

c) Protection against excess current (e.g. by thermal relays), including starting current, if provided for power circuits, is to be for not less than twice the full load current of the motor or circuit so protected, and is to be arranged to permit the passage of the appropriate starting currents.

d) Where fuses are fitted, their current ratings are to be two step higher than the rated current of the motors. However, in the case of intermittent service motors, the fuse rating is not to exceed 160% of the rated motor current.

e) The instantaneous short-circuit trip of circuit breakers is to be set to a value not greater than 15 times the rated current of the drive motor.

f) The protection of control circuits is to correspond to at least twice the maximum rated current of the circuit, though not, if possible, below 6 A.

2.6.6 Starting and stopping of motors for steering gear power units

a) Motors for power units are to be capable of being started and stopped from a position on the navigation bridge and from a point within the steering gear compartment.

b) Means are to be provided at the position of motor starters for isolating any remote control starting and stopping devices (e.g. by removal of the fuse-links or switching off the automatic circuit breakers).

c) Main and auxiliary steering gear power units are to be arranged to restart automatically when power is restored after a power failure.

2.6.7 Separation

a) Duplicated electric power circuits are to be separated as far as practicable.

b) Cables for duplicated electric power circuits with their associated components are to be separated as far as practicable. They are to follow different routes separated both vertically and horizontally, as far as practicable, throughout their entire length.

c) Duplicated steering gear control systems with their associated components are to be separated as far as practicable.

d) Cables for duplicated steering gear control systems with their associated components are to be separated as far as practicable. They are to follow different routes separated both vertically and horizontally, as far as practicable, throughout their entire length.

e) Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles are to be separated as far as practicable.

Where physical separation is not practicable, separation may be achieved by means of a fire-retardant plate.

f) All electrical components of the steering gear control systems are to be duplicated. This does not require duplication of the steering wheel or steering lever.

g) If a joint steering mode selector switch (uniaxial switch) is employed for both steering gear control systems, the connections for the control systems are to be divided accordingly and separated from each other by an isolating plate or air gap.

h) In the case of double follow-up control, the amplifier is 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, it is to be ensured that the follow-up amplifier is protected selectively.

i) Control circuits for additional control systems, e.g. steering lever or autopilot, are to be designed for all-pole disconnection.

j) The feedback 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.

k) Actuators controlling the power systems of the steering gear, e.g. magnetic valves, are to be duplicated and separated.

2.7 Alarms and indications

2.7.1 Power units

a) In the event of a power failure to any one of the steering gear power units, an audible and visual alarm shall be given on the navigating bridge and at a suitable main machinery control position.

b) Means for indicating that the motors of electric and electrohydraulic steering gear are running shall be installed on the navigating bridge and at a suitable main machinery control position.

c) Where a three-phase supply is used, an alarm shall be provided that will indicate failure of any one of the supply phases.

d) An overload alarm shall be provided for each motor of electric or electrohydraulic steering gear power units.

e) The alarms required in c) and d) shall be both audible and visual and situated in a conspicuous position in the main machinery space or control room from which the main machinery is normally controlled and on the navigation bridge.

2.7.2 Hydraulic system

a) Hydraulic oil reservoirs are to be provided with the alarms required in [2.5.6].

b) Where hydraulic locking, caused by a single failure, may lead to loss of steering, an audible and visual alarm, which identifies the failed system, is to be provided on the navigating bridge.

Note 1: This alarm is to be activated when, for example:

- the position of the variable displacement pump control system does not correspond with the given order, or
- an incorrect position in the 3-way valve, or similar, in the constant delivery pump system is detected.

2.7.3 Control system

a) In the event of a failure of electrical power supply to the steering gear control systems, an audible and visual alarm shall be given on the navigating bridge and at a suitable main machinery control position.

b) The most probable failures that may cause reduced or erroneous system performance (e.g. uncontrolled movements of rudder) are to be identified and automatically detected. All failure identified are to initiate audible and individual visual alarm on the navigation bridge.

At least the following failure scenarios are to be considered:

- Earth fault on AC and DC circuits
- Loop failures in closed loop systems, both command and feedback loops (normally short circuit, broken connections and earth faults)
- Data communication errors
- Programmable system failures (Hardware and software failures)
- Deviation between rudder order and feedback.

Note 1: Deviation alarm are to initiate 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 and autopilot). Deviation alarm may be caused by mechanical, hydraulic or electrical failures.

c) An indication (or an alarm) is to be given on the navigating bridge in the event that the steering gear remote control system is not available (e.g. the steering gear control is from the local control position).

2.7.4 Rudder angle indication

The angular position of the rudder is to be:

a) a) indicated on the navigating bridge, if the main steering gear is power operated. The rudder angle indication is to be independent of the steering gear control system and be supplied through the emergency switchboard, or by an alternative and independent source of electrical power such as that referred to in [2.6.2], item e);

b) rb) recognisable in the steering gear compartment, as applicable, or at the local steering control position. If a rudder angle indication is provided, this shall be independent of the one of item a)..

2.7.5

The failures (as defined but not limited to those in [2.7.3] a) and b)) likely to cause uncontrolled movements of rudder are to be clearly identified and in the event of detection of such failure, the rudder is to stop in the current position without manual intervention or, subject to the discretion of the Society, is to return to the mid/neutral position. For mechanical failures such as sticking valves and failure of static components (pipes, cylinders), the system response without manual intervention is not mandatory, and the operator can follow instructions on the signboard in case of such failures, in accordance with [4.5.1].

2.7.6 Summary table

Displays and alarms are to be provided in the locations indicated in Tab 5.

Table 5 : Location of displays and alarms

Item	Display	Alarms (audible and visible)	Location		
			Navigation Bridge	Engine Control Room	Steering gear compartment
Power failure of each power unit		X	X	X	
Indication that electric motor of each power unit is running	X		X	X	
Overload of electric motor of each power unit		X	X	X **(1)**	
Phase failure of electric motor of each power unit		X	X	X **(1)**	
Low level of each hydraulic fluid reservoir		X	X	X **(1)**	
Power failure of each control system		X	X	X	
Hydraulic lock		X	X		
Rudder angle indicator	X		X		X
Remote control system not available	X		X		
Failures listed in [2.4.3] b)		X	X		

(1) or in the machinery space, for yachts with attended machinery spaces.

3 Design and construction - Requirements for yachts equipped with non-traditional propulsion and steering systems, such as thrusters

3.1 Principle

3.1.1 General

s equipped with non-traditional propulsion and steering systems, such as thrusters, are to comply with the provisions of this Section, as far as applicable, and with the content of this Article.

For yachts fitted with propulsion and steering systems other than traditional arrangements, the main and auxiliary steering gear referred to in [2.1] may consist of thrusters of the following types:

- azimuth thrusters
- water-jets
- cycloidal propellers

complying with the provisions of Sec 12, as far as applicable.

Based on the type of the proposed steering system the angle metioned in [2.1.2] b) and [2.1.3] b) of steering may be reduced.

In particular the above angle of steering may be reduced for steering system as POD and similar systems for which the manoeuvrability of the yachts is assured by the application of a relevant evolution torque defined by the thrust of the specific propulsor (screw, stern drive propulsion engines) for which, considering the efficiency of such propulsors, adequate condition of manoeuvrability may be assured also with reduced angle of steering.

Under the acceptance of the above condition during the sea trial it is to be verified that adequate condition of manoeuvrability are assured at lower speed.

In this way the above condition (reduction of the steering angle) in general is not acceptable for surface propulsion systems for which at reduced speed it is in general expected a lower efficiency of the relevant propulsors.

3.1.2 Actuation system

Thrusters and other non-traditional propulsion and steering systems used as steering means are to be fitted with a main actuation system and an auxiliary actuation system.

When the yacht is fitted with multiple non-traditional propulsion and steering systems, such as but not limited to those in [6.1.1], the above requirement is considered satisfied if each of the non-traditional propulsion and steering systems is equipped with its own dedicated steering gear in compliance with [6.2.3].

3.1.3 Control system

Where the steering means of the consists of two or more thrusters, their control system is to include a device ensuring an automatic synchronisation of the thruster rotation, unless each thruster is so designed as to withstand any additional forces resulting from the thrust exerted by the other thrusters.

3.1.4 Definition

"Declared steering angle limits" are the operational limits in terms of maximum steering angle, or equivalent according to the Manufacturer's guidelines for safe operation, also taking into account the vessel speed or propeller torque/speed or other limitation; the declared steering angle limits are to be declared by the directional control system Manufacturer; 's manoeuvrability tests are to be carried out with steering angles not exceeding the declared angle limits.

3.2 Use of azimuth thrusters

3.2.1 Azimuth thrusters used as sole steering means

Where the is fitted with one azimuth thruster used as the sole steering means, this thruster is to comply with [2.1.2], as applicable, except that:

a) the main actuation system is required to be capable of rotating the 's directional control system from one side to the other at the declared steering angle limits at an average rotational speed of at least 2,4°/s with the running ahead at maximum ahead service speed and to be operated by power where the expected steering torque exceeds 1,5 kN·m

b) the auxiliary actuation system is required to be capable of rotating the 's directional control system from one side to the other at the declared steering angle limits at an average rotational speed of at least 0,5°/s with the running ahead at one half of the maximum ahead service speed, and to be operated by power in any having more than 2500 kW propulsion power per thruster unit or where the expected steering torque exceeds 3 kN·m.

3.2.2 Azimuth thrusters used as auxiliary steering gear

Where the auxiliary steering gear referred to in [3.2.1] or [4.2.1] consists of one or more azimuth thrusters, at least one such thruster is to capable of:

- steering the at maximum ahead service speed
- being brought speedily into action in case of emergency
- an average rotational speed of at least 2,4°/s.

The auxiliary actuation system referred to in [3.1.2] need not be fitted.

3.2.3 Omission of the auxiliary actuation system

Where the steering means of the consists of two independent azimuth thrusters or more, the auxiliary actuation system referred to in [3.1.2] need not be fitted provided that:

- "the thrusters are so designed that the can be steered with any one thruster out of operation and each of the steering systems is arranged so that after a single failure in its piping or in one of the power units, steering capability (but not individual steering system operation) can be maintained or speedily regained (e.g. by the possibility of positioning the thruster in a neutral steering position in an emergency, if needed), and
- each of the thrusters is fitted with two or more identical power units, capable of satisfying the requirements in [3.2.1] a) while any one of the power units is out of operation

3.3 Use of water-jets

3.3.1

The use of water-jets as steering means is subject to the requirements given in [3.2] as far as applicable; other arrangements will be given special consideration by the Society.

3.4 Electromechanics steering systems

3.4.1

In case of an electromechanics steering system the electrical system is to be approved.

3.4.2

3.4.2The mechanic actuators have to be certified according Pt A Ch 2 App.3.

4 Arrangement and installation

4.1 4.1Steering gear room/compartment arrangement

4.1.1 The steering gear compartment shall be:

a) readily accessible and separated from machinery spaces, and

b) provided with suitable arrangements to ensure working access to steering gear machinery and controls. These arrangements shall include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

4.2 Rudder actuator installation

4.2.1

a) Rudder actuators are to be installed on foundations of strong construction so designed as to allow the transmission to the yacht structure of the forces resulting from the torque applied by the rudder and/or by the actuator, considering the strength criteria defined in [2.4.3] and [4.3.1]. The structure of the in way of the foundations is to be suitably strengthened.

b) Where the rudder actuators are bolted to the hull, the grade of the bolts used is not to be less than 8.8. Unless the bolts are adjusted and fitted with a controlled tightening, strong shocks are to be fitted in order to prevent any lateral displacement of the rudder actuator.

4.3 Overload protections

4.3.1 Mechanical rudder stops

a) The steering gear is to be provided with strong rudder stops capable of mechanically stopping the rotation of the rudder at an angle slightly greater than its maximum working angle. Alternatively, these stops may be fitted on the to act on another point of the mechanical transmission system between the rudder actuator and the rudder blade.

b) The scantlings of the rudder stops and of the components transmitting to the ’s structure the forces applied on these stops are to be determined for the greater value of the torques T_R or T_G.

   Where $T_G \geq 1,5 T_R$, the rudder stops are to be fitted between the rudder actuator and the rudder stock, unless the rudder stock as well as all the components transmitting mechanical forces between the rudder actuator and the rudder blade are suitably strengthened.

4.3.2 Rudder angle limiters

a) Power-operated steering gear is to be provided with positive arrangements, such as limit switches, for stopping the gear before the rudder stops are reached. These arrangements are to be synchronised with the gear itself and not with the steering gear control.

b) Special consideration will be given to power-operated steering gear where the rudder may be oriented to more than 35°.

4.3.3 Relief valves

Relief valves are to be fitted in accordance with [2.5.5].

4.3.4 Buffers

Buffers are to be provided on all s fitted with mechanical steering gear. They may be omitted on hydraulic gear equipped with relief valves or with calibrated bypasses.

4.4 Means of communication

4.4.1 A means of communication is to be provided between the navigation bridge and the steering gear compartment or the steering gear control position.

If electrical, it is to be fed through the emergency switchboard or to be sound powered.

4.5 Operating instructions

4.5.1 For steering gear comprising two identical power units intended for simultaneous operation, both normally provided with their own (partly or mutually) separate control systems, the following standard notice is either to be placed on a signboard fitted at a suitable place on the steering control post on the bridge or incorporated into the operation manual:

CAUTION

IN SOME CIRCUMSTANCES WHEN 2 POWER UNITS ARE RUNNING SIMULTANEOUSLY, THE RUDDER MAY NOT RESPOND TO THE HELM. IF THIS HAPPENS STOP EACH PUMP IN TURN UNTIL CONTROL IS REGAINED.

5 Certification, inspection and testing

5.1 Type tests of hydraulic pumps

5.1.1 Each type of power unit pump is to be subjected in the workshop to a type test of not less than 100 hours' duration.

The test arrangements are to be such that the pump may run both:

- in idling conditions, and
- at maximum delivery capacity at maximum working pressure.

During the test, idling periods are to be alternated with periods at maximum delivery capacity at maximum working pressure. The passage from one condition to another is to occur at least as quickly as on board.

During the test, no abnormal heating, excessive vibration or other irregularities are permitted.

After the test, the pump is to be disassembled and inspected.

Note 1: Type tests may be waived for a power unit which has been proven to be reliable in marine service.

5.2 Testing of materials

5.2.1 Components subject to pressure or transmitting mechanical forces

a) Materials of components subject to pressure or transmitting mechanical forces, specifically:
   - cylindrical shells of hydraulic cylinders, rams and piston rods
   - tillers, quadrants
   - rotors and rotor housings for rotary vane steering gear
   - hydraulic pump casings
   - and hydraulic accumulators, if any,

   are to be duly tested, including examination for internal defects, in accordance with the requirements of Part D and when required in Pt A, Ch 2, App 3.

b) A works' certificate may be accepted for low stressed parts, provided that all characteristics for which verification is required are guaranteed by such certificate.

5.2.2 Hydraulic piping, valves and accessories

Tests for materials of hydraulic piping, valves and accessories are to comply with the provisions of Sec 10, [17.3].

5.3 Inspection and tests during manufacturing

5.3.1 Components subject to pressure or transmitting mechanical forces

a) The mechanical components referred to in [5.2.1] are to be subjected to appropriate non-destructive tests. For hydraulic cylinder shells, pump casings and accumulators, refer to Sec 5.

b) Defects may be repaired by welding only on forged parts or steel castings of weldable quality. Such repairs are to be conducted under the supervision of the Surveyor in accordance with the applicable requirements of Part D.

5.3.2 Hydraulic piping, valves and accessories

Hydraulic piping, valves and accessories are to be inspected and tested during manufacturing in accordance with Sec 10, [21], for a class I piping system when required in Pt A, Ch 2, App.3.

5.4 Inspection and tests after completion

5.4.1 Hydrostatic tests

a) Hydraulic cylinder shells and accumulators are to be subjected to hydrostatic tests according to the relevant provisions of Sec 3.

b) Hydraulic piping, valves and accessories and hydraulic pumps are to be subjected to hydrostatic tests according to the relevant provisions of Sec 10, [17.4].

5.4.2 board tests

After installation on board the steering gear is to be subjected to the tests detailed in Sec 16, [3.10].

5.4.3 Sea trials

For the requirements of sea trials, refer to Sec 16.

SECTION 12 THRUSTER

1 General

1.1 Application

1.1.1 The requirements of this Section apply to the following types of thrusters:

- Transverse thrusters intended for manoeuvring developing power equal to 500 kW or more
- Thrusters intended for propulsion, steering and dynamic positioning developing power equal to 220 kW or more; for power less than 220 kW the requirements apply only to the propeller and relevant shaft.

For azimuth thrusters intended for dynamic positioning, the additional requirements in Pt F, Ch 13, Sec 6 of Tasneef Rules for the Classification of Ships are to be complied with.

For yachtss with an ice class notation, the additional requirements in Part F, Chapter 9 are to be complied with, except for transverse thrusters not intended for dynamic positioning.

1.1.2 Thrusters developing power less than that indicated in [1.1.1] are to be built in accordance with sound marine practice and tested as required in [3.2] to the satisfaction of the Surveyor.

[3] is applicable when requested in accordance with the relevant Table of Pt A, Ch 2, App 3.

1.2 Definitions

1.2.1 Transverse thruster

A transverse thruster is an athwart thruster developing a thrust in a transverse direction for manoeuvring purposes.

1.2.2 Azimuth thruster

An azimuth thruster is a thruster which has the capability to develop thrust in any direction through 360°.

1.2.3 Water-jet

A water-jet is equipment constituted by a tubular casing (or duct) enclosing an impeller. The shape of the casing is such as to enable the impeller to produce a water-jet of such intensity as to give a positive thrust. Water-jets may have means for deviating the jet of water in order to provide a steering function.

1.2.4 Continuous duty thruster

A continuous duty thruster is a thruster which is designed for continuous operation, such as a propulsion thruster.

1.2.5 Intermittent duty thruster

An intermittent duty thruster is a thruster designed for operation at full power for a period not exceeding 1 hour, followed by operation at reduced rating for a limited period of time not exceeding a certain percentage of the hours in a day and a certain (lesser) percentage of the hours in a year. In general, athwart thrusters are intermittent duty thrusters.

1.3 Thrusters intended for propulsion

1.3.1 In general, at least two azimuth thrusters are to be fitted in s where these are the sole means of propulsion. Single azimuth thruster installations will be specially considered by the Society on a case by case basis.

Single water-jet installations are permitted.

1.4 Documentation to be submitted

1.4.1 Plans to be submitted for athwart thrusters and azimuth thrusters

For thrusters:

- intended for propulsion, steering and dynamic positioning
- intended for manoeuvring developing power equal to 500 kW or more,

the plans listed in Tab 1 are to be submitted. Plans as per item 6 of Tab 1 are also to be submitted for thrusters developing power less than 500 kW.

1.4.2 Plans to be submitted for water-jets

The plans listed in Tab 2 are to be submitted.

1.4.3 Additional data to be submitted

The data and documents listed in Tab 3 are to be submitted by the manufacturer together with the plans.

2 Design and Construction

2.1 Materials

2.1.1 Propellers

For requirements relative to material intended for propellers, see Sec 8.

2.1.2 Other thruster components

For the requirements relative to materials intended for other parts of the thrusters, such as gears, shaft, couplings, etc., refer to the applicable parts of the Rules.

Table 1 : Plans to be submitted for athwart thrusters and azimuth thrusters

No.	A/I **(1)**	ITEM
General requirements for all thrusters		
1	I	General arrangement of the thruster
2	A	Propeller, including the applicable details mentioned in Sec 8
3	A	Bearing details
4	A	Propeller and intermediate shafts
5	A	Gears, including the calculations according to Sec 6 for cylindrical gears or standards recognised by the Society for bevel gears
Specific requirements for transverse thrusters		
6	A	Structure of the tunnel showing the materials and their thickness
7	A	Structural equipment or other connecting devices which transmit the thrust from the propeller to the tunnel
8	A	Sealing devices (propeller shaft gland and thruster-tunnel connection)
9	A	For the adjustable pitch propellers: pitch control device and corresponding monitoring system
Specific requirements for rotating and azimuth thrusters		
10	A	Structural items (nozzle, bracing, etc.)
11	A	Structural connection to hull
12	A	Rotating mechanism of the thruster
13	A	Thruster control system
14	A	Piping systems connected to thruster
(1) A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

Table 2 : Plans to be submitted for water-jets

No.	A/I **(1)**	ITEM
1	I	General arrangement of the water-jet
2	A	Casing (duct) (location and shape) showing the materials and the thicknesses as well as the forces acting on the hull
3	A	Details of the shafts, flanges, keys
4	I	Sealing gland
5	A	Bearings
6	A	Impeller

No.	A/I **(1)**	ITEM
7	A	Steering and reversing buckets and their control devices as well as the corresponding hydraulic diagrams
(1) A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

Table 3 : Data and documents to be submitted for athwart thrusters, azimuth thrusters and water-jets

No.	A/I **(1)**	ITEM
1	I	Rated power and revolutions
2	I	Rated thrust
3	A	Material specifications of the major parts, including their physical, chemical and mechanical properties
4	A	Where parts of thrusters are of welded construction, all particulars on the design of welded joints, welding procedures, heat treatments and non-destructive examinations after welding
5	I	Where applicable, background information on previous operating experience in similar applications
(1) A = to be submitted for approval in four copies I = to be submitted for information in duplicate		

2.2 Transverse thrusters and azimuth thrusters

2.2.1 Prime movers

a) Diesel engines intended for driving thrusters are to comply with the applicable requirements of Sec 2.

b) Electric motors intended for driving thrusters and their feeding systems are to comply with the requirements of Chapter 2. In particular:

- Provisions are to be made to prevent starting of the motors whenever there are insufficient generators in operation.
- Intermittent duty thrusters will be the subject of special consideration by the Society.

2.2.2 Propellers

a) For propellers of thrusters intended for propulsion, steering and dynamic positioning, the requirements of Sec 8 apply.

b) For propellers of thrusters intended for manoeuvring only, the requirements of Sec 8 also apply, although the increase in thickness of 10% required in Sec 8, [2.5] does not need to be applied.

2.2.3 Shafts

a) For propeller shafts of thrusters, the requirements of Sec 7 apply to the portion of propellershaft between the inner edge of the aftermost shaft bearing and the inner face of the propeller boss or the face of the integral propeller shaft flange for the connection to the propeller boss.

b) For other shafts of thrusters, the requirement of Sec 6, [3.4.2] apply.

2.2.4 Gears

a) Gears of thrusters intended for propulsion steering and dynamic positioning are to be in accordance with the applicable requirements of Sec 6 for cylindrical gears or standards recognised by the Society for bevel gears, applying the safety factors for propulsion gears.

b) Gears of thrusters intended for manoeuvring only are to be in accordance with the applicable requirements of Sec 6, for cylindrical gears or Standards recognised by the Society for bevel gears, applying the safety factors for auxiliary gears.

2.2.5 Nozzles and connections to hull for azimuth thrusters

a) For the requirements relative to the nozzle structure, see Part B, Chapter 10.

b) The scantlings of the nozzle connection to the hull and the welding type and size will be specially considered by the Society, which reserves the right to require detailed stress analysis in the case of certain high power installations.

c) For steerable thrusters, the equivalent rudder stock diameter is to be calculated in accordance with the requirements of Part B, Chapter 10.

2.2.6 Transverse thruster tunnel

a) The thickness of the tunnel is not to be less than the adjacent part of the hull.

b) Special consideration will be given by the Society to tunnels connected to the hull by connecting devices other than welding.

2.2.7 Bearings

Bearing are to be identifiable and are to have a life adequate for the intended purpose. However, their life cannot be less than 2000 hours, a lesser value may be considered by the Society.

Table 4 : Azimuth thrusters

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			Thruster			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Steering oil pressure	L						
Oil tank level	L						

2.3 Water-jets

2.3.1 Shafts

The diameter of the shaft supporting the impeller, measured at bottom of keyway or at spline inner diameter, is not to be less than the diameter d_2, in mm, obtained by the following formula:

$$d_2 = 100fh \cdot \left(\frac{P}{N}\right)^{1/}$$

where:

P : Power, in kW

N : Rotational speed, in rpm

f : Calculated as follows:

$$f = \left(\frac{560}{R_m + 160}\right)^{1/3}$$

where R_m is the ultimate tensile strength of the shaft material, in N/mm^2

h : 1 when the shaft is only transmitting torque loads, and when the weight and thrust of the propeller are totally supported by devices located in the fixed part of the thruster

1,22 otherwise.

The shafts are to be protected against corrosion by means of either a continuous liner or an oil-gland of an approved type, or by the nature of the material of the shaft.

2.3.2 Casings and impellers

Casings and impellers are subject of special consideration by the Society.

2.3.3 Steering performance

Steering performance and emergency steering availability are to be at least equivalent to the requirements in Sec 11, [6.2] and Sec 11, [6.3].

2.4 Alarm, monitoring and control systems

2.4.1 General

In addition to those of this item, the general requirements given in Chapter 3 apply.

In the case of s with automation notations, the requirements in Part F, Chapter 2 also apply.

2.4.2 Steering thruster controls

a) Controls for steering are to be provided from the navigating bridge, the machinery control station (if any) and locally.

b) Means are to be provided to stop any running thruster at each of the control stations.

c) A thruster angle indicator is to be provided at each steering control station. The angle indicator is to be independent of the control system.

2.4.3 Alarm and monitoring equipment

Tab 4 summarises the minimum alarm and monitoring requirements for propulsion and steering thrusters. See also Sec 11, [6].

3 Testing and certification

3.1 Material tests

3.1.1 Propulsion and steering thrusters

All materials intended for parts transmitting torque and for propeller/impeller blades are to be tested in accordance with the applicable requirements of Sec 6, [5.2] or Sec 7, [4.1] or Sec 8, [4.1] in the presence of a Surveyor.

3.1.2 Transverse thrusters

Material testing for parts of athwart thrusters does not need to be witnessed by a Surveyor, provided full test reports are made available to him.

3.2 Testing and inspection

3.2.1 Thrusters

Thrusters are to be inspected as per the applicable requirements given in the Rules for the specific components.

3.2.2 Prime movers

Prime movers are to be tested in accordance with the requirements applicable to the type of mover used.

3.3 Certification

3.3.1 Certification of thrusters

Thrusters are to be individually tested and certified by the Society when required in Pt A Ch 2 App 3.

3.3.2 Mass produced thrusters

Mass produced thrusters may be accepted within the framework of the type approval program of the Society.

3.4 Type approved thruster

3.4.1 Issue of Tasneef Type Approval Certificate

When allowed in Pt A Ch 2 App 3 the thrusters defined in [1.1.1] as an alternative may be type approved by the Society.

For a particular type of thruster, a Tasneef Type Approval Certificate valid for 3 years can be obtained by the Manufacturer by testing a prototype according to the requirements contained in [3.1] and [3.2].

The validity of the certificate in the course of the 3 years is subject to satisfactory results of shop trials witnessed by a Tasneef Surveyor; the periodicity and procedures are to be agreed with Tasneef on a case-by-case basis.

During the period of the Certificate's validity, and for the next engines of the same type, the tests required by the Rules can be carried out by the Manufacturer, who will issue a Certificate of conformity to the prototype.

3.4.2 Renewal of Tasneef Type Approval Certificate

For the renewal of the Tasneef Type Approval Certificate, the tests to be carried out will be specified in a scheme to be agreed with the Society.

SECTION 13 REFRIGERATING INSTALLATIONS

1 General

1.1 Application

1.1.1 Refrigerating installations on all yachts

The minimum safety requirements addressed in this Section are to be complied with for any refrigerating plant installed on board a yacht to be classed by the Society.

2 Minimum design requirements

2.1 Refrigerating installation components

2.1.1 General

In general, the specific requirements stated in Part C of the Rules for various machinery and equipment are also applicable to refrigerating installation components.

2.1.2 Pressure vessels and heat exchangers

a) Pressure vessels of refrigerating plants are to comply with the relevant requirements of Sec 5.
b) Vessels intended to contain ammonia or toxic substances are to be considered as class 1 pressure vessels.
c) The materials used for pressure vessels are to be appropriate to the fluid that they contain. Where ammonia is the refrigerant, copper, bronze, brass and other copper alloys are not to be used.
d) Notch toughness of steels used in low temperature plants is to be suitable for the thickness and the lowest design temperature. A check of the notch toughness properties may be required where the working temperature is below minus 40°C.

2.1.3 Piping systems

a) Refrigerant pipes are generally to be regarded as pressure pipes.
b) Refrigerant, brine and sea water pipes are to satisfy the requirements of Sec 10, as applicable.
c) Refrigerant pipes are to be considered as belonging to the following classes:
   - class I: where they are intended for ammonia or toxic substances
   - class II: for other refrigerants
   - class III: for brine.
d) In general, the pipes conveying the cooling medium are not to come into direct contact with the 's structure; they are to be carefully insulated on their run outside the refrigerated spaces, and more particularly when passing through bulkheads and decks.
e) The materials used for the pipes are to be appropriate to the fluids that they convey. Copper, brass, bronze and other copper alloys are not to be used for pipes likely to convey ammonia. Methods proposed for joining such pipes are to be submitted to the Society for consideration.
f) Notch toughness of the steels used is to be suitable for the application concerned.
g) Where necessary, cooling medium pipes within refrigerated spaces or embedded in insulation are to be externally protected against corrosion; for steel pipes, this protection is to be ensured by galvanisation or equivalent. All useful precautions are to be taken to protect the joints of such pipes against corrosion.
h) The use of plastic pipes will be considered by the Society on a case by case basis.

2.2 Refrigerants

2.2.1 Prohibited refrigerants

The use of the following refrigerants is not allowed for board installations:

- Methyl chloride

- R11 - Trichloromonofluoromethane ($C\ Cl_3\ F$)
- Ethane
- Ethylene
- Other substances with lower explosion limit in air of less than 3,5%.

2.2.2 Statutory requirements

Particular attention is to be paid to any limitation on the use of refrigerants imposed by MARPOL Annex VI Regulation 12 and by the Administration of the State whose flag the yacht is flying.

2.2.3 Toxic or flammable refrigerants

The arrangement of refrigerating machinery spaces of plants using toxic or flammable refrigerants will be the subject of special consideration by the Society.

For specific requirements on spaces intended for plants using ammonia as a refrigerant see Pt C, Ch 1, Sec 13, [2.3] of the Tasneef Rules for the Classification of Ships and for those using carbon dioxide see Pt C, Ch 1, Sec 13, [2.4] of the Tasneef Rules for the Classification of Ships.

SECTION 14 TURBOCHARGERS

1 General

1.1 Application

1.1.1

These Rules apply to turbochargers with regard to design approval, type testing and certification and their matching on engines.

1.1.2

Turbochargers are to be type approved, either separately or as a part of an engine. The requirements are written for exhaust gas driven turbochargers, but apply in principle also for engine driven chargers.

The requirements escalate with the size of the turbochargers. The parameter for size is the engine power (at MCR) supplied by a group of cylinders served by the actual turbocharger, (e.g. for a V-engine with one turbocharger for each bank the size is half of the total engine power).

1.1.3

Turbochargers are categorized in three groups depending on served power by cylinder groups with:

- Category A: < 1000 kW
- Category B: > 1000 kW and < 2500 kW
- Category C: > 2500 kW

1.1.4 In the case of special types of turbochargers, the Society reserves the right to modify the requirements of this Section, demand additional requirements in individual cases and require that additional plans and data be submitted.

1.1.5

Turbochargers with an existing type approval on 1 January 2023 are not required to be re-type approved in accordance with this Section until the current Type Approval reaches its expiry date.

[3] is applicable when requested in accordance with the relevant Table of Pt A, Ch 2, App 3

1.2 Documentation to be submitted

1.2.1

The Manufacturer is to submit to the Society the following documents.

1.2.2

For Category A turbochargers:

On request:

- containment test report;
- cross sectional drawing with principal dimensions and names of components;
- test program.

1.2.3

For Category B and C turbochargers:

- cross sectional drawing with principal dimensions and materials of housing components for containment evaluation;
- documentation of containment in the event of disc fracture;
- operational data and limitations as;
- maximum permissible operating speed (rpm);
- alarm level for over-speed;
- maximum permissible exhaust gas temperature before turbine;
- alarm level for exhaust gas temperature before turbine;

- minimum lubrication oil inlet pressure;
- lubrication oil inlet pressure low alarm set point;
- maximum lubrication oil outlet temperature;
- lubrication oil outlet temperature high alarm set point;
- maximum permissible vibration levels, i.e. self- and externally generated vibration.

  (Alarm levels may be equal to permissible limits but shall not be reached when operating the engine at 110% power or at any approved intermittent overload be-yond the 110%);
- arrangement of lubrication system, all variants within a range;
- type test reports;
- test program.

1.2.4

For Category C turbochargers:

- drawings of the housing and rotating parts including details of blade fixing;
- material specifications (chemical composition and mechanical properties) of all parts mentioned above;
- welding details and welding procedure of above mentioned parts, if applicable;
- documentation of safe torque transmission when the disc is connected to the shaft by an interference fit, see [2.2.4];
- information on expected lifespan, considering creep, low cycle fatigue and high cycle fatigue;
- operation and maintenance manuals (see Note 1).

Note 1: Applicable to two sizes in a generic range of turbochargers.

1.2.5

When the turbochargers are manufactured by a licensee on the basis of a previously type approved licensor design, but using parts manufactured outside of the licensor premises and making use of other than the original licensor drawings and specifications, the licensee is to submit, for each turbocharger type, a list of all the drawings specified above, indicating for each drawing the relevant number and revision status from both licensor and licensee.

Where the licensee proposes design modifications to components, the associated documents are to be submitted by the licensee to the Society for approval, with a Licensor statement confirming acceptance of the changes.

In all cases, the licensee is to provide the Surveyor entrusted to carry out the testing, with a complete set of the documents specified above.

2 Design and construction

2.1 Application

2.1.1

The turbochargers shall be designed to operate under conditions given in Sec 1, [2.4] and Sec 1, [2.5].

The component lifetime and the alarm level for speed shall be based on 45°C air inlet temperature.

2.2 Materials

2.2.1

The requirements of Sec 5, [2.1.1] are to be complied with, as far as applicable, at the Society’s discretion.

2.3 Design

2.3.1 Stress analyses

a) For Category B and C turbochargers, the manufacturer is to submit a calculation report concerning the stresses on each rotor under the most severe service conditions.

b) The results of previous in-service experience on similar applications may be considered by the Society as an alternative to item a) above.

Data on the design service life and test results used to substantiate calculation assumptions are also to be provided.

2.3.2 Vibrations

The range of service speeds is not to give rise to unacceptable vibrations affecting the rotor and blades.

Calculations of the critical speeds including details of their basic assumptions are to be submitted for Category B and C turbochargers.

2.3.3 Containment *(1/1/2025)*

a) Turbochargers shall fulfil containment in the event of a rotor burst. This means that at a rotor burst no part may penetrate the casing of the turbocharger or escape through the air intake. For documentation purposes (test/calculation), it shall be assumed that the discs disintegrate in the worst possible way.

b) For category B and C, containment shall be documented by testing. Fulfilment of this requirement can be awarded to a generic range of turbochargers based on testing of one specific unit. Testing of a large unit is preferred as this is considered conservative for all smaller units in the generic range. In any case, it must be documented (e.g. by calculation) that the selected test unit really is representative for the whole generic range.

Note 1: A generic range means a series of turbocharger which are of the same design, but scaled to each other.

c) The minimum test speeds, relative to the maximum permissible operating speed, are:
   - for the compressor:120%
   - for the turbine: 140% or the natural burst speed, whichever is lower.

d) Containment tests shall be performed at temperature which is not lower than the maximum allowable temperature of the turbocharger to be specified by the manufacturer

e) Manufacturers are to determine whether cases more critical than those defined in [2.3.3], c) and [2.3.3], d) exist with respect to containment safety. Where such a case is identified, evidence of containment safety is also to be provided for that case

f) A numerical analysis simulation such as Finite Element Method (FEM)of sufficient containment integrity of the casing based on calculations by means of a simulation model may be accepted in lieu of the practical containment test, provided that:
   - the numerical simulation model has been tested and its suitability/accuracy has been proven by direct comparison between calculation results and the practical containment test for a reference application (reference containment test). This test shall be performed at least once by the manufacturer for acceptance of the numerical simulation method in lieu of tests;
   - the corresponding numerical simulation for the containment is performed for the same speeds as specified for the containment test;
   - material properties for high-speed deformations are to be applied in the numeric simulation. The correlation between normal properties and the properties at the pertinent deformation speed are to be substantiated;
   - the design of the turbocharger regarding geometry and kinematics is to be similar to the turbocharger that was used for the reference containment test.

g) In cases where a totally new design is adopted for a turbocharger for which an application for type approval certification has been requested, new reference containment tests are to be performed.

Note 2: Totally new design means the principal differences between a new turbocharger and previous ones are related to geometry and kinematics. The turbochargers are to be regarded as having a totally new design if the structure and/or material of the turbocharger casings are changed, or any of, but not limited to, the following items is changed from the previous design.
   - Maximum permissible exhaust gas temperature
   - Number of bearings
   - Number of turbine blades
   - Number of turbine wheels and/or compressor wheels
   - Direction of inlet air and/or exhaust gas (e.g., axial flow orientation, radial flow orientation)
   - Type of the turbocharger drive (e.g., axial turbine type, radial turbine type, mixed flow turbine type)

2.3.4 Disc-shaft shrinkage fit

For Category C turbochargers, in cases where the disc is connected to the shaft with interference fit, calculations shall substantiate safe torque transmission during all relevant operating conditions such as maximum speed, maximum torque and maximum temperature gradient combined with minimum shrinkage amount.

2.3.5 Bearings

a) Turbine bearings are to be so located that their lubrication is not impaired by overheating from hot gases or adjacent hot parts.

b) Lubricating oil is to be prevented from dripping on high temperature parts.

c) Roller bearings are to be identifiable and are to have a life adequate for their intended purpose.

2.3.6 Welded fabrication *p*

The manufacturer's requirements relative to the welding of turbine rotors or major forged or cast pieces, where permitted, are to be readily identifiable by the Society in the plans submitted for approval.

Requirements relative to fabrication, welding, heat treatments, examinations, testing and acceptance will be stipulated on a case by case basis.

In general, all welding is to be carried out by qualified welders in accordance with qualified welding procedures using approved consumables.

2.4 Alarms and Monitoring

2.4.1

For all turbochargers of Categories B and C, indications and alarms as listed in Tab 1 are required.

2.4.2

Indications may be provided at either local or remote locations.

Table 1

Pos.	Monitored Parameters	Category of Turbochargers				Notes
		B		C		
		Alarm	Indication	Alarm	Indication	
1	Speed	High **(4)**	X **(4)**	High **(4)**	X **(4)**	
2	Exhaust gas at each turbocharger inlet, temperature	High **(1)**	X **(1)**	High	X	High temp. alarms for each cylinder at engine is acceptable **(2)**
3	Lub. oil at turbocharger outlet, temperature			High	X	If not forced system, oil temperature near bearings
4	Lub. oil at turbocharger outlet, temperature	Low	X	Low	X	Only for forced lubrication systems **(3)**

(1) For Category B turbochargers, the exhaust gas temperature may be alternatively monitored at the turbocharger outlet, provided that the alarm level is set to a safe level for the turbine and that correlation between inlet and outlet temperatures is substantiated.

(2) Alarm and indication of the exhaust gas temperature at turbocharger inlet may be waived if alarm and indication for individual exhaust gas temperature is provided for each cylinder and the alarm level is set to a value safe for the turbocharger.

(3) Separate sensors are to be provided if the lubrication oil system of the turbocharger is not integrated with the lubrication oil system of the diesel engine or if it is separated by a throttle or pressure reduction valve from the diesel engine lubrication oil system.

(4) On turbocharging systems where turbochargers are activated sequentially, speed monitoring is not required for the turbocharger(s) being activated last in the sequence, provided all turbo-chargers share the same intake air filter and they are not fitted with waste gates.

3 Type tests, material tests, workshop inspection and testing, certification

3.1 Type testing

3.1.1

Applicable to Categories B and C.

3.1.2

The type test for a generic range of turbochargers may be carried out either on an engine (for which the turbocharger is foreseen) or in a test rig.

3.1.3 *(1/1/2025)*

Turbochargers for the low, medium, and high-speed engines are to be subjected to at least 500 load cycles at the limits of operation. This test may be waived if the turbocharger together with the engine is subjected to this kind of low cycle testing, according to Sec 2 The suitability of the turbocharger for such kind of operation is to be preliminarily stated by the manufacture.

3.1.4

The rotor vibration characteristics shall be measured and recorded in order to identify possible sub-synchronous vibrations and resonances.

3.1.5

The type test shall be completed by a hot running test at maximum permissible speed combined with maximum permissible temperature for at least one hour. After this test, the turbo-charger shall be opened for examination, with focus on possible rubbing and the bearing conditions.

3.1.6

Normally the surveyor's presence during the various parts of the type tests is required.

3.2 Workshop inspections and testing

3.2.1

The manufacturer shall adhere to a quality system designed to ensure that the designer's specifications are met, and that manufacturing is in accordance with the approved drawings; the verification of compliance with this requirement is within the scope of a Type approval.

3.2.2

For category C, this shall be verified by means of periodic product audits of an Alternative Certification Scheme (ACS) (Pt A, Ch 2, App 3) by the Society.

These audits shall focus on:

- chemical composition of material for the rotating parts;
- mechanical properties of the material of a representative specimen for the rotating parts and the casing;
- UT and crack detection of rotating parts;
- dimensional inspection of rotating parts;
- rotor balancing;
- hydraulic testing of cooling spaces to 4 bars or 1.5 times maximum working pressure, whichever is higher;
- overspeed test of all compressor wheels for a duration of 3 minutes at either 20% above alarm level speed at room temperature or 10% above alarm level speed at 45°C inlet temperature when tested in the actual housing with the corresponding pressure ratio. The over-speed test may be waived for forged wheels that are individually controlled by an approved non-destructive method.

3.3 Type approval certificate and its validity

3.3.1 Issue of Type approval

When foreseen in Pt A Ch 2 App.3 the turbocharger defined in [1.1.1] may be type approved by The Society.

For a particular type of turbocharger, a Tasneef Type Approval Certificate valid for 3 years can be obtained by the maker by testing a prototype according to the requirements contained in [2] and subject to the satisfactory outcome of the type tests specified in [3.1] and a factory audit specified in [3.2.1], the Society will issue to the turbocharger Manufacturer a Type Approval Certificate valid for all turbochargers of the same type.

Where changes are made to a turbocharger and upon satisfactory review of documents as per [1.2.2], the extension to the modified turbocharger of the validity of the type tests and containment test previously carried out will be evaluated on a case by case basis.

The validity of the certificate in the course of the 3 years is subject to satisfactory results of shop trials witnessed by a Tasneef Surveyor; the periodicity and procedures are to be agreed with Tasneef on a case-by-case basis.

During the period of the Certificate's validity, and for the next engines of the same type, the tests required by the Rules can be carried out by the Manufacturer, who will issue a Certificate of conformity to the prototype

3.3.2 Renewal of type Approval

For the renewal of the Tasneef Type Approval Certificate, thep tests to be carried out will be specified in a scheme to be agreed with the Society.

3.4 Testing certification

3.4.1 *(1/1/2025)*

Turbochargers shall be delivered with:

- For category C, a society certificate, which as a minimum cites the applicable type approval and the Alternative Certification Scheme (ACS), when ACS applies.
- For category B, a work's certificate, which at a minimum cites the applicable type approval, which includes production assessment according to [3.2.1].

3.4.2

The same applies to replacement of rotating parts and casing.

3.4.3

Rotating parts of category C turbochargers are to be marked for easy identification with the appropriate certificate.

3.4.4

Alternatively to the Alternative Certification Scheme and periodic product audits according to [3.2.2] individual certification of a turbocharger and its parts may be made at the discretion of the Society. However, such individual certification of category C turbocharger and its parts shall also be based on test requirements specified in [3.2.2].

SECTION 15 ANCHOR WINDLASS

1 General

1.1 Application

1.1.1 *(1/1/2025)*

A windlass used for handling anchors, suitable for the size of chain cable and complying with the following criteria is to be fitted. Windlasses are also to comply with requirements given in Pt B, Ch 1, Sec 3, [6].

1.2 Standards of compliance

1.2.1

The design, construction and testing of windlasses are to conform to an acceptable standard or code of practice. To be considered acceptable, the standard or code of practice is to specify criteria for stresses, performance and testing.

1.2.2

The following are examples of standard recognized:

- SNAME T & R Bulletin 3-15:2018 - Guide to the Design and Testing of Anchor Windlasses for Merchant s
- ISO 7825:2017 - Deck machinery general requirements
- ISO 4568:2006 - building - Seagoing vessels - Windlasses and anchor capstans
- JIS F6714:1995 - Windlasses.

1.3 Documentation to be submitted

1.3.1

The following plans showing the design specifications, the standard of compliance, engineering analyses and details of construction, as applicable, are to be submitted to the Society for evaluation:

a) windlass design specifications; anchor and chain cable particulars; anchorage depth; performance criteria; standard of compliance;

b) windlass arrangement plan showing all of the components of the anchoring/mooring system such as the prime mover, shafting, cable lifter, anchors and chain cables; mooring winches, wires and fairleads, if they form part of the windlass machinery; brakes; controls; etc;

c) windlass arrangement plan showing all of the components of the anchoring/mooring system such as the prime mover, shafting, cable lifter, anchors and chain cables; mooring winches, wires and fairleads, if they form part of the windlass machinery; brakes; controls; etc;

d) hydraulic system, to include:
   1) piping diagram along with system design pressure,
   2) safety valves arrangement and settings,
   3) material specifications for pipes and equipment,
   4) typical pipe joints, as applicable, and
   5) technical data and details for hydraulic motors;

e) electric one line diagram along with cable specification and size; motor controller; protective device rating or setting; as applicable;

f) control, monitoring and instrumentation arrangements;

g) engineering analyses for torque-transmitting and load-bearing components demonstrating their compliance with recognized standards or codes of practice. Analyses for gears are to be in accordance with a recognized standard;

h) plans and data for windlass electric motors including associated gears rated 100 kW and over;

i) calculations demonstrating that the windlass prime mover is capable of attaining the hoisting speed, the required continuous duty pull, and the overload capacity are to be submitted if the "load testing" including "overload" capacity of the entire windlass unit is not carried out at the shop (see b)).

2 Design and construction

2.1 Materials

2.1.1

Materials used in the construction of torque-transmitting and load-bearing parts of windlasses are to comply with the requirements of Part D or of a national or international material standard. The proposed materials are to be indicated in the construction plans and are to be approved in connection with the design. All such materials are to be certified by the material manufacturers and are to be traceable to the manufacturers' certificates.

2.2 Welded fabrication

2.2.1

Weld joint designs are to be shown in the construction plans and are to be approved in association with the approval of the windlass design. Welding procedures and welders are to be qualified in accordance with the requirements of Pt D, Ch 5. Welding consumables are to be approved by the Society in the case their type and grade fall within the scope of Pt D, Ch 5, Sec 2, [1] to [8]; when their type and grade fall outside the scope of Pt D, Ch 5, Sec 2, [1] to [8], the welding consumables are to comply with Pt D, Ch 5, Sec 2, [9], [10], [11] and [12] or to national or international standards. The degree of non-destructive examination of welds and post-weld heat treatment, if any, are to be specified and submitted for consideration.

3 Design

3.1 General

3.1.1 Application

Along with and notwithstanding the requirements of the chosen standard of compliance, the following requirements are also to be complied with. In lieu of conducting engineering analyses and submitting them for review, approval of the windlass mechanical design may be based on a type test, in which case the testing procedure is to be submitted for consideration.

The structure and the support structure of windlasses and chain stopper are to comply with the requirements of Part B.

3.2 Mechanical design

3.2.1 Design loads

a) Holding loads

Calculations are to be made to show that, in the holding condition (single anchor, brake fully applied and chain cable lifter declutched), and under a load equal to 80% of the specified minimum breaking strength of the chain cable, the maximum stress in each load bearing component will not exceed yield strength (or 0.2% proof stress) of the material. For installations fitted with a chain cable stopper, 45% of the specified minimum breaking strength of the chain cable may instead be used for the calculation.

b) Inertia loads

The design of the drive train, including prime mover, reduction gears, bearings, clutches, shafts, cable lifter and bolting is to consider the dynamic effects of sudden stopping and starting of the prime mover or chain cable so as to limit inertial load.

3.2.2 Continuous Duty Pull

The windlass prime mover is to be able to exert for at least 30 minutes a continuous duty pull (e.g., 30-minute short time rating corresponding to S2-30 min. of IEC 60034-1), P_{C1}, in kN, corresponding to the grade and diameter, d, of the chain cables as given in Tab 1.

Table 1 : Continuous duty pull

Material of chain cables	Continuous duty pull, in kN
Mild steel	$P_{C1} = 0,0375\ d^2$
High tensile strength steel	$P_{C1} = 0,0425\ d^2$
Very high tensile strength steel	$P_{C1} = 0,0475\ d^2$
Note 1: d: chain cable diameter, in mm.	

The values of the above table are applicable when using ordinary stockless anchors for anchorage depth down to 82.5 m.

For anchorage depth deeper than 82.5 m, a continuous duty pull P_{C2}, in kN, is to be taken as:

$$P_{C2} = P_{C1} + 0,00027\ d^2\ (D - 82,5)$$

where:

D : anchor depth, in m.

The anchor masses are to be taken as specified in Pt B, Ch 10, Sec 4, [2.1]. Also, the value of PC is based on the hoisting of one anchor at a time, and that the effects of buoyancy and hawse pipe efficiency (assumed to be 70%) have been accounted for. In general, stresses in each torque-transmitting component are not to exceed 40% of yield strength (or 0.2% proof stress) of the material under these loading conditions.

3.2.3 Overload capability

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 and it is to be provided for at least two minutes.

The speed in this overload period may be lower than the nominal speed specified in [3.2.4].

3.2.4 Hoisting speed

The mean speed of the chain cable during hoisting of the anchor and cable is to be at least 0.15 m/s. For testing purposes, the speed is to be measured over two shots of chain cable and initially with at least three shots of chain (82.5 m in length) and the anchor submerged and hanging free.

3.2.5 Brake capacity

The capacity of the windlass brake is to be sufficient to stop the anchor and chain cable when paying out the chain cable. Where a chain cable stopper is not fitted, the brake is to produce a torque capable of withstanding a pull equal to 80% of the specified minimum breaking strength of the chain cable without any permanent deformation of strength members and without brake slip. Where a chain cable stopper is fitted, 45% of the breaking strength may instead be applied.

3.2.6 Chain cable stopper

Chain cable stopper, if fitted, along with its attachments is to be designed to withstand, without any permanent deformation, 80% of the specified minimum breaking strength of the chain cable.

3.3 Hydraulic system

3.3.1

Hydraulic systems where employed for driving windlasses are to comply with the requirements of Pt C, Ch 1, Sec 10, [13].

3.4 Electrical system

3.4.1 Electric motors

Electric motors are to meet the requirements of Pt C, Ch 2, Sec 4 and those rated 100 kW and over are to be certified. Motors exposed to weather are to have enclosures suitable for their location as provided for in the requirements of Pt C, Ch 2, Sec 3, [4]. Where gears are fitted, they are to meet the requirements of Pt C, Ch 2, Sec 8 and those rated 100 kW and over are to be certified.

3.4.2 Electrical circuits

Motor branch circuits are to be protected in accordance with the requirements of Pt C, Ch 2, Sec 3, [7.10] and cable sizing is to be in accordance with the requirements of Pt C, Ch 2, Sec 3, [9]. Electrical cables installed in locations subjected to the sea are to be provided with effective mechanical protection.

3.5 Protection of mechanical components

3.5.1

To protect mechanical parts including component housings, a suitable protection system is to be fitted to limit the speed and torque at the prime mover. Consideration is to be given to a means to contain debris consequent to a severe damage of the prime mover due to overspeed in the event of uncontrolled rendering of the cable, particularly when an axial piston type hydraulic motor forms the prime mover.

3.6 Couplings

3.6.1

Windlasses are to be fitted with couplings which are capable of disengaging between the cable lifter and the drive shaft. Hydraulically or electrically operated couplings are to be capable of being disengaged manually.

4 Workshop inspection and testing

4.1 General

4.1.1

Windlasses are to be inspected during fabrication at the manufacturers' facilities by a Surveyor for conformance with the approved plans. Acceptance tests, as specified in the specified standard of compliance, are to be witnessed by the Surveyor and include the test described in [4.2], as a minimum.

4.2 Tests

4.2.1 No-load test

The windlass is to be run without load at nominal speed in each direction for a total of 30 minutes. If the windlass is provided with a gear change, additional run in each direction for 5 minutes at each gear change is required.

4.2.2 Load test

The windlass is to be tested to verify that the continuous duty pull, overload capacity and hoisting speed as specified in [3.2] can be attained.

Where the manufacturing works does not have adequate facilities, these tests, including the adjustment of the overload protection, can be carried out on board. In these cases, functional testing in the manufacturer's works is to be performed under no-load conditions.

4.2.3 Brake capacity test

The holding power of the brake is to be verified either through testing or by calculation.

5 Marking

5.1 General

5.1.1

Windlass shall be permanently marked with the following information:

a) nominal size of the windlass (e.g. 100/3/45 is the size designation of a windlass for 100 mm diameter chain cable of Grade 3, with a holding load of 45 % of the breaking load of the chain cable);

b) maximum anchorage depth, in metres.

SECTION 16 TESTS ON BOARD

1 General

1.1 Application

1.1.1 This Section covers board tests, both at the moorings and during sea trials. Such tests are additional to the workshop tests required in the other Sections of this Chapter.

1.2 Purpose of board tests

1.2.1 Shipboard tests are intended to demonstrate that the main and auxiliary machinery and associated systems are functioning properly, in particular in respect of the criteria imposed by the Rules. The tests are to be witnessed by a Surveyor.

1.3 Documentation to be submitted

1.3.1 A comprehensive list of the board tests intended to be carried out by the yard is to be submitted to the Society.

For each test, the following information is to be provided:

- scope of the test
- parameters to be recorded.

2 General requirements for board tests

2.1 Trials at the moorings

2.1.1 Trials at the moorings are to demonstrate the following:

a) satisfactory operation of the machinery in relation to the service for which it is intended

b) quick and easy response to operational commands

c) safety of the various installations, as regards:
   - the protection of mechanical parts
   - the safeguards for personnel

d) accessibility for cleaning, inspection and maintenance.

Where the above features are not deemed satisfactory and require repairs or alterations, the Society reserves the right to require the repetition of the trials at the moorings, either wholly or in part, after such repairs or alterations have been carried out.

2.2 Sea trials

2.2.1 Scope of the tests

Sea trials are to be conducted after the trials at the moorings and are to include the following:

a) demonstration of the proper operation of the main and auxiliary machinery, including monitoring, alarm and safety systems, under realistic service conditions

b) check of the propulsion capability when one of the essential auxiliaries becomes inoperative

c) detection of dangerous vibrations by taking the necessary readings when required

d) checks either deemed necessary for classification or requested by the interested parties and which are possible only in the course of navigation in open sea.

2.2.2 Exemptions

Exemption from some of the sea trials may be considered by the Society in the case of s having a sister yacht for which the satisfactory behaviour in service is demonstrated.

Such exemption is, in any event, to be agreed upon by the interested parties and is subject to the satisfactory results of trials at the moorings to verify the safe and efficient operation of the propulsion system.

3 Shipboard tests for machinery

3.1 Conditions of sea trials

3.1.1 Displacement of the

Except in cases of practical impossibility, or in other cases to be considered individually, the sea trials are to be carried out at a displacement as close as possible to the deadweight (full load).

3.1.2 Power of the machinery

a) The power developed by the propulsion machinery in the course of the sea trials is to be as close as possible to the power for which classification has been requested. In general, this power is not to exceed the maximum continuous power at which the weakest component of the propulsion system can be operated. In cases of diesel engines and gas turbines, it is not to exceed the maximum continuous power for which the engine type concerned has been approved.

b) Where the rotational speed of the shafting is different from the design value, thereby increasing the stresses in excess of the maximum allowable limits, the power developed in the trials is to be suitably modified so as to confine the stresses within the design limits.

3.1.3 Determination of the power and rotational speed

a) The rotational speed of the shafting is to be recorded in the course of the sea trials, preferably by means of a continuous counter.

b) In general, the power is to be determined by means of torsiometric readings, to be effected with procedures and instruments deemed suitable by the Society.

   As an alternative, for reciprocating internal combustion engines and gas turbines, the power may be determined by measuring the fuel consumption and on the basis of the other operating characteristics, in comparison with the results of bench tests of the prototype engine.

   Other methods of determining the power may be considered by the Society on a case by case basis.

3.2 Navigation and manoeuvring tests

3.2.1 Speed trials

a) Where required by the Rules (see Pt A, Ch 1, Sec 2, [4.9.4]), the speed of the yacht is to be determined using procedures deemed suitable by the Society.

b) The yacht speed is to be determined as the average of the speeds taken in not less than two pairs of runs in opposite directions.

3.2.2 Astern trials

a) The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, and so to bring the to rest within reasonable distance from maximum ahead service speed, shall be demonstrated and recorded.

b) The stopping times, yacht headings and distances recorded on trials, together with the results of trials to determine the ability of s having multiple propellers to navigate and manoeuvre with one or more propellers inoperative, shall be available on board for the use of the Master or designated personnel.

c) Where the yacht is provided with supplementary means for manoeuvring or stopping, the effectiveness of such means shall be demonstrated and recorded as referred to in paragraphs a) and b).

d) Main propulsion systems are to undergo tests to demonstrate the astern response characteristics. The tests are to be carried out at least over the manoeuvring 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.

e) The reversing characteristics of the propulsion plant, including the blade pitch control system of controllable pitch propellers, are to be demonstrated and recorded during trials.

For electric propulsion systems, see [3.7].

3.3 Tests of diesel engines

3.3.1 General

a) The purpose of the board testing is to verify compatibility with power transmission and driven machinery in the system, control systems and auxiliary systems necessary for the engine and integration of engine / board control systems, as well as other items that had not been dealt with in the FAT (Factory Acceptance Testing)

b) Where the machinery installation is designed for residual or other special fuels, the ability of engines to burn such fuels is to be demonstrated.

c) Tests other than those listed below may be required by statutory instruments (e.g. EEDI verification).

3.3.2 Starting capacity

Starting manoeuvres are to be carried out in order to verify that the capacity of the starting media satisfies the required number of start attempts.

3.3.3 Monitoring and alarm system

The monitoring and alarm systems are to be checked to the full extent for all engines, except items already verified during the works trials.

3.3.4 Test loads

Test loads for various engine applications are given below in [3.4.5] to [3.4.9]. In addition, the scope of the trials may be expanded depending on the engine application, service experience, or other relevant reasons.

3.3.5 Main propulsion engines driving fixed propeller or impellers *(1/1/2025)*

a) at rated engine speed n_0: at least 1 hour

b) at engine speed n = 1,032 n_0 for 30 minutes

Note 1: The test in b) is to be performed only where permitted by the engine adjustment, see Note 3 to Sec 2, [7.4.4]

c) at approved intermittent overload (if applicable): testing for duration as agreed with the manufacturer

d) minimum engine speed to be determined

e) the ability of reversible engines to be operated in reverse direction is to be demonstrated.

Note 2: To be carried out during stopping tests according to Resolution MSC.137 (76), see [3.4.10] for additional requirements in the case of a barred speed range.

Note 3: The test in e) may be performed during the dock or sea trials.

3.3.6 Main propulsion engines driving controllable pitch propellers

a) At rated engine speed n_0 with a propeller pitch leading to rated engine power (or to the maximum achievable power if 100% cannot be reached): at least 4 hours

b) At approved intermittent overload (if applicable): testing for duration as agreed with the manufacturer

c) With reverse pitch suitable for manoeuvring, see [3.4.10] for additional requirements in the case of a barred speed range.

3.3.7 Engines driving generators for electrical propulsion and/or main power supply

a) At 100% power (rated electrical power of generator): at least 60 min

b) At 110% power (rated electrical power of generator): at least 10 min

c) Demonstration of the generator prime movers' and governors' ability to handle load steps as described in Sec 2.

Note 1: Each engine is to be tested 100% electrical power for at least 60 min and 110% of rated electrical power of the generator for at least 10 min. This may, if possible, be done during the electrical propulsion plant test, which is required to be tested with 100% propulsion power (i.e. total electric motor capacity for propulsion) by distributing the power on as few generators as possible. The duration of this test is to be sufficient to reach stable operating temperatures of all rotating machines or for at least 4 hours. When some of the gen. set(s) cannot be tested due to insufficient time during the propulsion system test mentioned above, those required tests are to be carried out separately.

3.3.8 Propulsion engines also driving power take off (PTO) generator

a) 100% engine power (MCR) at corresponding speed n_0: at least 4 hours

b) 100% propeller branch power at engine speed n_0 (unless already covered in a): 2 hours

c) 100% PTO branch power at engine speed n_0: at least 1 hour.

3.3.9 Engines driving auxiliaries

a) 100% power (MCR) at corresponding speed n0: at least 30 min

b) Approved intermittent overload: testing for duration as approved. board generating sets, account is to be taken of the times needed to actuate the generator's overload protection system.

3.3.10 Torsional vibrations

Barred speed range

Where a barred speed range is required, passages through this barred speed range, both accelerating and decelerating, are to be demonstrated. The times taken are to be recorded and are to be equal to or below those times stipulated in the approved documentation, if any. This also includes when passing through the barred speed range in reverse rotational direction, especially during the stopping test.

Note 1: Applies both for manual and automatic passing-through systems.

The 's draft and speed during all these demonstrations is to be recorded. In the case of a controllable pitch propeller, the pitch is also to be recorded.

The engine is to be checked for stable running (steady fuel index) at both upper and lower borders of the barred speed range. Steady fuel index means an oscillation range less than 5% of the effective stroke (idle to full index).

3.4 Tests of gas turbines

3.4.1 Main propulsion turbines

Main turbines are to be subjected during dock trials and subsequent sea trials to the following tests:

- operation at rated rpm for at least 3 hours
- reversing manoeuvres.

During the various operations, the pressures, temperatures and relative expansion are not to assume magnitudes liable to endanger the safe operation of the plant.

During the trials all safety, alarm, shut-off and control systems associated to the turbine are to be tested or properly simulated.

3.4.2 Auxiliary turbines

Turbines driving electric generators or auxiliary machines are to be run for at least 1 hours at their rated power and for 30 minutes at 110% of rated power.

During the trials all safety, alarm, shut-off and control systems associated to the turbine are to be tested or properly simulated.

3.5 Tests of electric propulsion system

3.5.1 Dock trials

a) The dock trials are to include the test of the electrical production system, the power management and the load limitation.

b) A test of the propulsion plant at a reduced power, in accordance with dock trial facilities, is to be carried out. During this test, the following are to be checked:
   - Electric motor rotation speed variation
   - Functional test, as far as practicable (power limitation is to be tested with a reduced value)
   - Protection devices
   - Monitoring and alarm transmission including interlocking system.

c) Prior to the sea trials, an insulation test of the electric propulsion plant is to be carried out.

3.5.2 Sea trials

Testing of the performance of the electric propulsion system is to be effected in accordance with an approved test program.

This test program is to include at least:

a) Speed rate of rise

b) Endurance test:
   - 4 hours at 100% rated output power
   - 2 hours at the maximum continuous output power normally used at sea

- 10 minutes at maximum astern running power

c) Check of the crash astern operation in accordance with the sequence provided to reverse the speed from full ahead to full astern, in case of emergency. During this test, all necessary data concerning any effects of the reversing of power on the generators are to be recorded, including the power and speed variation

d) Test of functionality of electric propulsion, when manoeuvring and during the turning test

e) Test of power management performance: reduction of power due to loss of one or several generators to check, in each case, the power limitation and propulsion availability.

3.6 Tests of gears

3.6.1 Tests during sea trials

During the sea trials, the performance of reverse and/or reduction gearing is to be verified, both when running ahead and astern.

In addition, the following checks are to be carried out:

- check of the bearing and oil temperature
- detection of possible gear hammering, where required by Sec 9, [3.6.1]
- test of the monitoring, alarm and safety systems.

3.6.2 Check of the tooth contact

a) Prior to the sea trials, the tooth surfaces of the pinions and wheels are to be coated with a thin layer of suitable coloured compound.

   Upon completion of the trials, the tooth contact is to be inspected. The contact marking is to appear uniformly distributed without hard bearing at the ends of the teeth and without preferential contact lines.

   The tooth contact is to comply with Tab 1.

b) The verification of tooth contact at sea trials by methods other than that described above will be given special consideration by the Society.

c) In the case of reverse and/or reduction gearing with several gear trains mounted on roller bearings, manufactured with a high standard of accuracy and having an input torque not exceeding 20 000 N·m, the check of the tooth contact may be reduced at the Society's discretion.

   Such a reduction may also be granted for gearing which has undergone long workshop testing at full load and for which the tooth contact has been checked positively.

   In any case, the teeth of the gears are to be examined by the Surveyor after the sea trials. Subject to the results, additional inspections or re-examinations after a specified period of service may be required.

Table 1 : Tooth contact for gears

Heat treatment and machining	Percentage of tooth contact	
	across the whole face width	of the tooth working depth
quenched and tempered, cut	70	40
• quenched and tempered, shaved or ground • surface-hardened	90	40

3.7 Tests of main propulsion shafting and propellers

3.7.1 Shafting alignment

Where alignment calculations are required to be submitted in pursuance of Sec 7, [3.3.1], the alignment conditions are to be checked on board as follows:

a) shafting installation and intermediate bearing position, before and during assembling of the shafts:
   - optical check of the relative position of bushes after fitting
   - check of the flanged coupling parameters (gap and sag)
   - check of the centring of the shaft sealing glands

b) engine (or gearbox) installation, with floating :
   - check of the engine (or gearbox) flanged coupling parameters (gap and sag)

- check of the crankshaft deflections before and after the connection of the engine with the shaft line, by measuring the variation in the distance between adjacent webs in the course of one complete revolution of the engine

Note 1: The is to be in the loading conditions defined in the alignment calculations.

c) load on the bearings:
   - check of the intermediate bearing load by means of jack-up load measurements
   - check of the bearing contact area by means of coating with an appropriate compound.

3.7.2 Shafting vibrations

Torsional, bending and axial vibration measurements are to be carried out where required by Sec 9. The type of the measuring equipment and the location of the measurement points are to be specified.

3.7.3 Bearings

The temperature of the bearings is to be checked under the machinery power conditions specified in [3.1.2].

3.7.4 Stern tube sealing gland

The stern tube oil system is to be checked for possible oil leakage through the stern tube sealing gland.

3.7.5 Propellers

a) For controllable pitch propellers, the functioning of the system controlling the pitch from full ahead to full astern position is to be demonstrated. It is also to be checked that this system does not induce any overload of the engine.
b) The proper functioning of the devices for emergency operations is to be tested during the sea trials.

3.8 Tests of piping systems

3.8.1 Functional tests

During the sea trials, piping systems serving propulsion and auxiliary machinery, including the associated monitoring and control devices, are to be subjected to functional tests at the nominal power of the machinery. Operating parameters (pressure, temperature, consumption) are to comply with the values recommended by the equipment manufacturer.

3.8.2 Performance tests

The Society reserves the right to require performance tests, such as flow rate measurements, should doubts arise from the functional tests.

3.9 Tests of steering gear

3.9.1 General

a) The steering gear is to be tested during the sea trials under the conditions stated in [3.1] in order to demonstrate, to the Surveyor's satisfaction, that the applicable requirements of Sec 11 are fulfilled.
b) For controllable pitch propellers, the propeller pitch is to be set at the maximum design pitch approved for the maximum continuous ahead rotational speed.
c) If the cannot be tested at the deepest draught, steering gear trials shall 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 the rudder is fully submerged (zero speed waterline) and the vessel is in an acceptable trim condition, or the rudder load and torque at the specified trial loading condition have been predicted and extrapolated to the full load condition. In any case, the speed of corresponding to the number of maximum continuous revolution of main engine and maximum design pitch applies.

3.9.2 Tests to be performed

Tests of the steering gear are to include at least:

a) functional test of the main and auxiliary steering gear with demonstration of the performances required by Sec 11, [3.3] and Sec 11, [4.3].
b) test of the steering gear power units, including transfer between steering gear power units
c) test of the isolation of one power actuating system, checking the time for regaining steering capability
d) test of the hydraulic fluid refilling system
e) test of the alternative power supply required by Sec 11, [2.3.2], item e)
f) test of the steering gear controls, including transfer of controls and local control

g) test of the means of communication between the navigation bridge, the engine room and the steering gear compartment
h) test of the alarms and indicators
i) where the steering gear design is required to take into account the risk of hydraulic locking, a test is to be performed to demonstrate the efficiency of the devices intended to detect this.

Note 1: Tests d) to i) may be carried out either during the mooring trials or during the sea trials.

Note 2: For s of less than 500 tons gross tonnage and for fishing vessels, the Society may accept departures from the above list, in particular to take into account the actual design features of their steering gear.

Note 3: Azimuth thrusters are to be subjected to the above tests, as far as applicable.

3.10 Tests of anchor windlasses

3.10.1 General

a) 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 cable lifter, proper transit of the chain through the hawse pipe and the chain pipe, and effecting proper stowage of the chain and the anchor;
b) it is to be confirmed that anchors properly seat in the stored position and that chain stoppers function as designed if fitted. The mean hoisting speed, as specified in Sec 15, [3.2.4], is to be measured and verified. 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 is to be specially considered by the Society.

4 Inspection of machinery after sea trials

4.1 General

4.1.1

a) For all types of propulsion machinery, those parts which have not operated satisfactorily in the course of the sea trials, or which have caused doubts to be expressed as to their proper operation, are to be disassembled or opened for inspection.

   Machinery or parts which are opened up or disassembled for other reasons are to be similarly inspected.
b) Should the inspection reveal defects or damage of some importance, the Society may require other similar machinery or parts to be opened up for inspection.
c) An exhaustive inspection report is to be submitted to the Society for information.

4.2 Diesel engines

4.2.1

a) In general, for all diesel engines, the following items are to be verified:
   - the deflection of the crankshafts, by measuring the variation in the distance between adjacent webs in the course of one complete revolution of the engine
   - the cleanliness of the lubricating oil filters.

b) In the case of propulsion engines for which power tests have not been carried out in the workshop, some parts, agreed upon by the interested parties, are to be disassembled for inspection after the sea trials.

APPENDIX 1 ALTERNATIVES, RELAXATIONS AND ADDITIONAL CONSIDERATIONS FOR YACHTS OF LESS THAN 500 GT

1 General Requirements (Sec 1)

1.1 Fuels

1.1.1 With reference to Sec 1, [2.9] with reference to the use of fuel oil having flash points of less than 43°C the arrangement is considered by the Society on a case by case basis.

1.2 Communications

1.2.1 With reference to Sec 1, [3.8.1] these requirements may be relaxed at the Society's discretion, in any case at least one fixed means of voice communication is to be provided for communicating orders from the wheelhouse to the position in the machinery space or in the control room from which the speed and the direction of the thrust of the propellers are controlled.

2 Shafting arrangement (Sec 7)

2.1 Propeller shaft

2.1.1 *(1/1/2025)*

With reference to Sec 7, [2.2.3] as an alternative kp may be taken as 1,04.

2.2 Intermediate and propeller Shafts made of Corrosion resisting material

2.2.1 With reference to Sec 7, [2.2.3] for yachts of less than 300GT as an alternative [2.1.2] may be applied.

Proposal to use the formula in [2.1.2] for yachts between 300GT and 500GT will be evaluated on a case by case base by the Society.

2.2.2 Corrosion-resistant shaft materials *(1/1/2025)*

For corrosion-resistant material, such as Aquamet 17, Aquamet 22, Nickel copper alloy - monel K 500, stainless steel type 316 and duplex steels, the following alternative formula can be used instead of that stated in item [2.2.2] and [2.2.3] to calculate the minimum diameter of the intermediate and propeller shafts:

$D = K_m [P / (n \times R_t)]^{1/3}$

where:

k_m : Material factor (see Tab 1);

D : Rule diameter of the intermediate and propeller shafts (mm);

P : Maximum service power (kW);

N : Shaft rational speed, in r.p.m., corresponding to P;

R_t : Yield strength in torsional shear (N/mm^2) (see Tab 1).

Shafts for which the scantling is determined according to the previous formula are to comply with the criteria listed in items a) to f), irrespective of the shaft material

a) Torsional and lateral shaft vibration analysis carried out according to Sec 8 is to be submitted to Tasneef. If requested by Tasneef axial shaft vibration analysis is also to be submitted for approval;

b) the span between two consecutive supports of the shaft is to be not more than the value given by the formula as indicated in [2.1.3];

c) the ratio between shaft diameter and propeller diameter is to be, in general, not more than 14:1;

d) the length of the cone shaft is to be verified in order to check that the sectional area of the key is not less than the value in mm^2 given by the formula given in [2.1.5];

e) a visual inspection of the entire shaft is required at every intermediate survey, and an inspection with a non-destructive system may be requested by the Tasneef Surveyor. **Table 1 :**

Values of factor K_m and R_t *(1/1/2025)*

Material	Material factor (**K_m**)	Maximum value R_t (N/mm^2) to be introduced in the formula
Aquamet 17, Aquamet 22	650	500
Stainless steel type 316 (austenitic)	530	160
Nickel copper alloy - monel K 500	560	460
Duplex steels	500	500
Temet (duplex 2205)	620	450

2.2.3 Shaft bearing spacing

The maximum shaft bearing space is to be not more than the value given by the following formula:

$I = (0,7439 \times D)/N)^{1/2} \cdot (E/W_1)^{1/4}$

where:

I : maximum unsupported length (m);

D : shaft diameter (mm);

N : shaft speed (RPM);

E : modulus of elasticity of shaft material, in tension (MPa);

W_1 : shaft material specific weight (kg/dm^3).

The minimum required spacing for rigid bearings is to exceed 20 shaft diameters when possible, to facilitate the alignment.

2.2.4 Shaft bearing spacing

With reference to Sec 7, [2.5.5] b) as an alternative [2.1.5] may be applied.

2.2.5 Propeller shaft keys and keyways

The sectional area of the key subject to shear stress is to be not less than the value A, in mm^2, given by the following formula:

$$A = 155 \cdot \frac{d^3}{\sigma_t \cdot d_{PM}}$$

where:

d : is the Rule diameter calculated according to the formula in Sec 7, [2.2.2].

In any case R_m is to be assumed equal to 400 N/mm^2.

d_{pm} : is the diameter, in mm, of the cone at the middle length of the key

σ_t : is the specified minimum tensile strength (UTS) of the key material, in N/mm^2.

The effective area in crushing of key, shaft or boss is to be not less than:

$$A = 24 \cdot \frac{d^3}{\sigma_y \cdot d_{PM}}$$

where:

d : is the Rule diameter calculated according to the formula in Sec 7, [2.2.2].

In any case R_m is to be assumed equal to 400 N/mm^2.

d_{pm} : is the diameter, in mm, of the cone at the middle length of the key

σ_y : is the yield strength of the key, shaft boss material as appropriate, in N/mm^2.

3 Propellers

3.1 Propeller blade thickness

3.1.1 With reference to Sec 8 the value of propeller thicknesses in Sec 8, [2.2], [2.3] and [2.4] may be multiplied by 0.88.

4 Shaft vibrations

4.1 General

4.1.1 With reference to Sec 9, shaft vibrations are required only when the formula in [2.1.2] is applied to shafts made of corrosion resisting material.

5 Piping

5.1 Conditions of use of metallic materials

5.1.1 With reference to Sec 10, Tab 4: Conditions of use of metallic materials in piping systems.

Aluminium and aluminium alloys may be accepted in the engine spaces provided that they are suitably protected against the effect of heat for the following services:

- flammable oil systems
- sounding and air pipes of fuel oil tanks
- fire-extinguishing systems
- bilge system
- scuppers and overboard discharges.

Outside the engine spaces, proposals for the use of aluminium and aluminium alloy pipes may be accepted considering the fire risk of the compartment where such pipes are fitted.

In addition, for the above services in engine spaces the minimum thickness of such pipes is to be not less than 4 mm.

For scuppers and overboard discharges the above insulation and the above required thickness may be omitted provided that they are fitted at their ends with closing means operated from a position above the main deck.

5.2 Use of welded and threaded metallic joints

5.2.1 With reference to Sec 10, Tab 15: Use of welded and threaded metallic joints in piping systems

a) Sleeve tapered threaded joint are acceptable on pipes of class II and III with outside diameter of not more than 80mm.

b) Sleeve parallel threaded joint are acceptable on pipes of class III with outside diameter of not more than 80mm.

5.3 Mechanical Joints

5.3.1 With reference to Sec 10, Tab 16: Application of mechanical joints.

For scuppers, slip-on joints may be accepted if they are located in an easily accessible position provided that the scuppers are fitted at their ends with closing means operated from a position above the main deck; the relevant fire resistance will be considered on the basis of the fire risk of the compartment where they are fitted. As an alternative, closing means operated from a position above the main deck are not required if the slip-on joints are fitted above the water level of maximum immersion and additional supporting devices for the scupper pipe are fitted near the ends of the slip-on joint.

5.4 Flexible hoses

5.4.1 With reference to Sec 10, [2.51]: Flexible hoses.

Only for yachts on composite material of less than 300 GT in short range navigation hydraulic oil for not essential systems in machinery space and outside of machinery spaces and also for essential systems only outside the machinery spaces of category A the Society may evaluate on a case by case basis, taking into account the probability and consequences of failure due to the position and the arrangement, the use of flexible hoses for long lengths or even the entire length of the system.

5.4.2 For yachts of less than 100GT in short range navigation in some systems flexible hoses may be used for the entire length in accordance with Tab 2. Fire endurance of such flexible pipe is to be determined according to Tab 1.

Table 2 : For the fire endurance test of non metallic flexible hoses for yachts having GT<100, in short range navigation

Piping system	Location		
	Machinery spaces **(3) (4)**	Accommodation, service and control spaces **(5)**	Open decks
FLAMMABLE LIQUIDS (FLASHPOINT > 60°C)			
Fuel Oil	FTML	FTML	FTML
Lubricating Oil	FTML	FTML	FTML
FLAMMABLE LIQUIDS (FLASHPOINT > 150°C)			
Hydraulic Oil	FT	0	0
Hydraulic Steering Gear Oil	FTML	0	0 **(2)**
SEA WATER **(10)**			
Cooling Water, Essential Services	FT	FT	FT
Ballast	FT	FT	FT
FIRE SYSTEM **(10)**			
Fire Main And Water Spray	M	M	M
Foam System	FTML	FTML	FTML
Sprinkler System	M	M	M
Bilge Main And Branches	FTML	FTML	0
FRESH WATER			
Cooling Water, Essential Services	FT	FT	FT
Non-Essential Systems	0	0	0
SANITARY, DRAINS, SCUPPERS			

(1) Pipes fitted below the heaviest water level, and connected to sea inlet and overboard discharge are to be metallic structural pipes.
(2) Flexible hoses for hydraulic steering gear can be accepted on open deck if protected against mechanical damage by casing or equivalent means.
(3) Machinery spaces of category A are defined in Ch 4, Sec 1, [1.15].
(4) Spaces, other than category A machinery spaces, containing propulsion machinery and internal combustion engines, generators and major electrical machinery, pumps, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.
(5) Accommodation spaces, service spaces and control stations are defined in Ch 4, Sec 1, [1.1.1], [1.23], [1.9].
(6) Non-metallic flexible hoses are allowed only for the marine-engine wet-exhaust system.
(7) Exhaust gas pipes fitted below 1000 mm height from the water level, if no valve or overboard discharge is provided, are to be metallic structural pipes.
(8) For scuppers and draining coming from the open deck, M may be replaced by 0 if a remote control valve is to be fitted at vessel side, and suitable means are to be provided to blank the intake opening on deck.

SYMBOLS:
FT: the fire endurance test is to be carried out according to ISO 15540 and ISO 15541
FTML: in addition to the fire endurance test carried out according to ISO 15540 and ISO 15541, the flexible hose shall be used for short length, normally not more than 800 mm, a different length may be accepted if indicated in the relevant Certificates, and shall be placed in sight in well-lighted spaces.
M: for the services, the space and position indicated, only metallic non-flexible pipes can be fitted: the use of flexible hoses is not allowed
EG: tests on non-metallic flexible hoses for engine exhaust gas are to be carried out according to ISO 13363
0: fire endurance tests not required
NA: flexible hoses are not allowed for the services and the space indicated.

Piping system	Location		
	Machinery spaces **(3) (4)**	Accommodation, service and control spaces **(5)**	Open decks
Deck Drains (Internal)	FT	0	0
Sanitary Drains (Internal)	0	0	0
Scuppers And Discharges (Overboard): Fitted below heaviest water level	M	M	M
Scuppers And Discharges (Overboard): Fitted above heaviest water level	M **(8)**	M **(8)**	M **(8)**
SOUNDING, AIR			
Sounding pipes	NA	NA	NA
Water Tanks, Dry Spaces - air pipes	NA	NA	NA
Oil Tanks (FlashPoint > 60°C) - air pipes	M	M	M
Control Air	FT	FT	FT
Service Air	0	0	0
(Non-Essential)	0	0	0
Brine	0	0	0
ENGINE EXHAUST GAS			
Exhaust piping provided with valve on overboard discharge	EG **(6)**	NA	NA
Exhaust piping with no valve on overboard discharge: FITTED BELOW 1000 mm height from heaviest water level	M **(7)**	M **(7)**	NA
Exhaust piping with no valve on overboard discharge: FITTED AT OR ABOVE 1000 mm height from heaviest water level	EG **(6)**	EG **(6)**	NA

(1) Pipes fitted below the heaviest water level, and connected to sea inlet and overboard discharge are to be metallic structural pipes.
(2) Flexible hoses for hydraulic steering gear can be accepted on open deck if protected against mechanical damage by casing or equivalent means.
(3) Machinery spaces of category A are defined in Ch 4, Sec 1, [1.15].
(4) Spaces, other than category A machinery spaces, containing propulsion machinery and internal combustion engines, generators and major electrical machinery, pumps, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.
(5) Accommodation spaces, service spaces and control stations are defined in Ch 4, Sec 1, [1.1.1], [1.23], [1.9].
(6) Non-metallic flexible hoses are allowed only for the marine-engine wet-exhaust system.
(7) Exhaust gas pipes fitted below 1000 mm height from the water level, if no valve or overboard discharge is provided, are to be metallic structural pipes.
(8) For scuppers and draining coming from the open deck, M may be replaced by 0 if a remote control valve is to be fitted at vessel side, and suitable means are to be provided to blank the intake opening on deck.

SYMBOLS:
FT: the fire endurance test is to be carried out according to ISO 15540 and ISO 15541
FTML: in addition to the fire endurance test carried out according to ISO 15540 and ISO 15541, the flexible hose shall be used for short length, normally not more than 800 mm, a different length may be accepted if indicated in the relevant Certificates, and shall be placed in sight in well-lighted spaces.
M: for the services, the space and position indicated, only metallic non-flexible pipes can be fitted: the use of flexible hoses is not allowed
EG: tests on non-metallic flexible hoses for engine exhaust gas are to be carried out according to ISO 13363
0: fire endurance tests not required
NA: flexible hoses are not allowed for the services and the space indicated.

5.5 Through hull fitting

5.5.1 When on composite vessels the passage through the hull of sea inlets and overboard discharges is designed with a metallic cylindrical system, provided with flanges fixed or screwed, or a short pipe is fitted between the side valve and the hull, and directly welded to the plating, the minimum wall thickness of the stem/pipe is indicated in Tab 3.

A different wall thickness may be considered by the Society on a case-by-case basis, provided that it complies with recognised standards.

Where the through hull fittings are built in metals resistant to corrosion, or are protected against corrosion by means of coating, etc., thickness may be reduced at the discretion of the Society (as reference see Tab 4, Tab 5 and Tab 6.

The through hull fitting is to be type approved based on strength test agreed with the Society.

Table 3 : Thickness for through hull outfitting

External diameter (mm)	Minimum wall thickness (mm)
20	2,0
21,3 - 25,0	3,2
26,9 - 33,0	3,2
38,0 - 44,5	7,6
48,3	7,6
51,0 - 63,5	7,6
70,0	7,6
76,1 - 82,5	7,6
88,9 - 108,0	7,8
114,3 - 127,0	8,8
133,0 - 139,7	9,5
152,4 - 168,3	11
177,8	12,7
193,7	12,7
219,1	12,7
244,5 - 273,0	12,7
298,5 - 368,0	12,7
406,4 - 457,2	12,7

5.6 Level Gauges

5.6.1 With reference to Sec 10, [2.8.2]: Level Gauges.

Cylindrical gauges may be used provided they are fitted with self-closing valves at their lower end as well as at their upper end if the latter is below the maximum liquid level.

In the case of tanks not subject to filling by power pumps, with the exception of fuel oil service tanks, the valves need not be of the self-closing type. Such valves are, however, to be readily accessible and instruction plates are to be fitted adjacent to them specifying that they are to be kept closed.

5.7 Welding of steel piping

5.7.1 With reference to Sec 10, [3]: Welding of steel piping as an alternative what below may be applied:

a) Welded joints on class III piping systems are to be in conformity with sound marine practice.
b) Welded joints on class I and II piping systems are to be specially considered by the Society.
c) The location of welded joints is to be such that as many as possible can be made in a workshop. The location of welded joints to be made on board is to be so determined as to permit their joining and inspection in satisfactory conditions.

5.8 Bilge system

5.8.1 With reference to Sec 10, [6.2.2] a): Number and distribution of bilge suctions, for yachts of less than 300 GT the direct suction from the machinery space of category A is not mandatory.

5.8.2 With reference to Sec 10, [6.5.1]: Number and arrangement of pumps, for short range yachts, the second bilge pump and suction pipes may be portable.

5.8.3 With reference to Sec 10, [6.6.1] d) as an alternative what below may be applied.

In no case is the actual internal diameter to be:

- more than 5 mm smaller than that obtained from the formula given in a) or b), or
- less than 40 mm.

5.8.4 With reference to Sec 10, [6.6.3] a) as an alternative what below may be applied:

d_1 is not to be less than 25 mm and need not exceed 100 mm.

5.9 Scupper and sanitary discharges

5.9.1 With reference to Sec 10, Tab 23 in case of use of material other than steel the value given in Tab 4 or Tab 5 or Tab 6 according to the material of the pipe may be applied.

Table 4 : Minimum thickness of scupper and discharge pipes led to the shell for copper and copper alloys

External diameter (mm)	Copper		Copper alloy	
	normal thickness (mm)	substantial thickness (mm)	normal thickness (mm)	substantial thickness (mm)
8	1,0		0,8	
12	1,2		1,0	
25	1,5	3,5	1,2	3
50	2,0	4	1,5	3
88,9	2,5	4,3	2,0	3,5
114	3,0	6	2,5	5
133	3,0	6,5	2,5	5,5
193,7	3,5	7	3,0	6
273	4,0	7,5	3	6
Note 1: Intermediate sizes may be determined by interpolation.				

Table 5 : Minimum thickness of scupper and discharge pipes led to the shell for stainless steel

External diameter of the pipe d (mm)	Stainless Steel	
	normal thickness (mm)	substantial thickness (mm)
8,0	0,8	
12	1,0	
25,0	1,2	2,5
50,0	1,5	3
88,9	2,0	3,5
114	2,5	5
133,0	2,5	5,5
193,7	3,0	6
273,0	3,5	6,5
Note 1: Intermediate sizes may be determined by interpolation.		

Table 6 : Minimum thickness of scupper and discharge pipes led to the shell for Alluminium

	Alluminium	
External diameter of the pipe d (mm)	normal thickness (mm)	substantial thickness (mm)
0	1,5	
12	2,0	

	Alluminium	
External diameter of the pipe d (mm)	normal thickness (mm)	substantial thickness (mm)
43	2,5	5
51	2,5	5
70	3,0	5,7
76	3,0	5
108	4,0	7,8
159	4,5	11
219	5,0	12
Note 1: Intermediate sizes may be determined by interpolation.		

5.10 Air pipes, sounding and overflow pipes

5.10.1 With reference to Sec 10, [9.1.8] a) what follows may be applied.

The thickness of the pipes with diameter less than 50mm is to be at least 4mm.

5.10.2 With reference to Sec 10, [9.1.8] d) what follows may be applied.

The internal diameter of air pipes is not to be less than 38 mm; a lower value may be accepted for small tanks but in no case less than 25 mm.

5.10.3 With reference to Sec 10, [9.3.4] a) what follows may be applied.

The internal diameter of overflow pipes is not to be less than 38 mm.

5.10.4 With reference to Sec 10, [9.3.4] c) special consideration may be done in case all the storage fuel tanks are served by a common manifold and the tanks can be only filled one by one.

5.10.5 With reference to Sec 10, [9.3.4] also other material may be accepted.

5.11 Cooling system

5.11.1 For yachts of less than 300GT with 2 engines only 1 sea chest for each engine is acceptable provided that with only one engine the yacht can maintain a suitable speed and a reasonable maneuvering capability.

5.12 Fuel oil System

5.12.1 With reference to Sec 10, [11.4.1] b). Considerations may be done for the daily tanks in case operative instructions are foreseen.

5.12.2 With reference to Sec 10, [11.5.1]. Location of fuel oil tanks in craft constructed of aluminium or alluminium alloys or composite, the fuel tank may be done of the same material of the hull provided that the tanks are to be suitably protected against the effect of fire in the machinery space .

5.12.3 With reference to Sec 10, [11.9.2] Fuel oil Service tanks, only 1 service tank may be acceptable.

5.12.4 With reference to Sec 10, [11.9.4] Sampling point, for yachts of less than 400GT this paragraph applies as far as it is practicable.

5.12.5 With reference to Sec 10, [11.11.1]: Materials this paragraph is to be applied considering [5.1].

5.13 Lubricating oil System

5.13.1 With reference to Sec 10, [12.8.1]: Materials this paragraph is to be applied considering [5.1].

5.14 Hydraulic oil System

5.14.1 With reference to Sec 10, [13.7.1]: Materials this paragraph is to be applied considering [5.1].

5.15 Exhaust Gas System

5.15.1 With reference to Sec 10, [15.3]: Materials this paragraph is to be applied considering [5.1].

6 Steering System (Sec 11)

6.1 Design and construction

6.1.1 With reference to Sec 11, [2] the Society may accept an arrangement whereby the two steering gears units share common mechanical components (tiller, quadrant, rudder actuators) provided that any defect can be isolated so that steering capability can be maintained or speedily regained.

6.1.2 For planning hulls with conventional rudders the possibility to accept a reduction of the steering angle is based on the possibility to assure adequate manoeuvrability conditions at lower speed.

6.1.3 Hand operation
Hand operation of steering gear is permitted when it requires an effort less than 160 N.

6.1.4 During the sea trials the capability of the auxiliary steering gear, including hand operated systems are to be tested.

6.1.5 Hydraulic power supply
Hydraulic power installations supplying steering gear may also supply other equipment at the same time provided that the operation of the steering gear is not affected:

a) by the operation of this equipment, or
b) by any failure of this equipment or of its hydraulic supply piping.

6.1.6 Alarm and Indications
With reference to Sec.11 [2.7] what follows is acceptable.

a) Alarm and Indication: Control system [2.7.3] b) is not mandatory.
b) Alarm and Indication: Control system [2.7.5] is not mandatory.
c) Summary Table: Failures listed in [2.7.3] b) is not mandatory.

6.1.7 With reference to Sec 11, [2.5.6]: "Hydraulic reservoir" the storage means may consist of a readily accessible drum, of sufficient capacity to refill one power actuating system if necessary.

7 Anchor Windlass

7.1 General

7.1.1 Sec 15 is not mandatory.

8 Plastic Pipes (App 3)

8.1 General

8.1.1 With reference to App 3, Tab 1 what follow may be considered:

a) when Fuel lubricating or hydraulic oil are located in accommodation spaces service space and control stations or on open decks they may be L2.
b) Bilge lines located in accommodation spaces service space and control stations or on open decks that may be L2.

8.1.2 App 3, [2.3.2] is applicable as far as it is practicable and reasonable.

8.1.3 With reference to App 3, [3.6.2] the valve required may be omitted if the penetration is fitted at a distance more than B/3 from the sides and above the design waterline, or somehow protected with watertight divisions from minor hull damages.

9 Testing on board (Sec 16)

9.1 General

9.1.1 With reference to [3.2.2] d) the plan does not need to be provided.

9.1.2 With reference to [3.4.6] a) and [3.4.8] a) 4 hours may be reduced to 1 hour.

9.1.3 What required at [3.9.1] c) may not be applied.

APPENDIX 2 ALTERNATIVES, RELAXATIONS AND ADDITIONAL CONSIDERATIONS FOR YACHTS OF LESS THAN 24 M LLL

1 General (Sec 1)

1.1

1.1.1 With reference to Sec 1 the use of petrol fuel also for propulsion engines may be accepted provided that the requirements of the relevant ISO Standards 10088 and 11105 are to be complied with concerning the ventilation of the spaces where fuels are stored or engines are installed and relevant to the protection of electrical devices against ignition of surrounding flammable gases.

2 Diesel Engines (Sec 2)

2.1

2.1.1 With reference to Sec 2. For propulsion only the following certificates are required:

- Manufacturers' power declaration according to ISO Standard 8665;
- noise emission according to EN ISO Standard 14509;
- exhaust emission according to EN ISO Standard 8178.

3 Shafts (Sec 7)

3.1

3.1.1 With reference to Sec 7, this Section only applies to propeller shafts and intermediate shafts.

4 Piping (Sec 10)

4.1 Piping, connections and Use of flexible hoses

4.1.1 The requirements Sec 10, [2], [3], [4], [5] may be applied as far as it is practicable and at least what required in Tab 1 is to be applied. In Tab 1 are reported the minimum requirements applicable to piping for each system depending on the location.

The requirement of Sec 10 applies to Black water system as far as it is practicable and the system is to be in compliance at least to EN ISO 8099.

Table 1 : Use of flexible hoses

Requirements for each service and locations (1)		
System	Machinery space or other spaces with fire risk	Spaces without fire risk
Fuel oil system	Flexible hoses shall comply with the following requirements: • Hoses are to be in compliance with the ISO 7840 standard, type A1 or A2. • Hoses shall be used in agreement with the application limits required in the standard.	Flexible hoses shall comply with the following requirements: • as for machinery space; alternatively, hoses may be in compliance with the ISO 8461 standard, type B1 or B2. • Hoses shall be used in agreement with the application limits required in the standard.
Hydraulic oil system	Flexible hoses can be used, whatever the gross tonnage of the yacht, according to the following requirements. • Flexible hoses used for non essential services are not required to be fire resistant, but they are to be certified suitable for use by the manufacturer in compliance with national or international recognized standards. • Flexible hoses used for essential services (services whose failure can impair the safety of navigation); flexible hoses in compliance with [2.4] can be accepted: they shall be type approved according to [2.4.1] and fire resistant in compliance with ISO 15540/15541	Flexible hoses can be used, whatever the gross tonnage of the yacht, according to the following requirements. Flexible hoses are not required to be fire resistant, but they are to be certified suitable for use by the manufacturer in compliance with national or international recognized standards.
Fixed water fire extinguishing system	Flexible hoses shall comply with the following requirements: • They shall be made of material suitable to be used for the intended service and capable of maintaining their integrity at a maximum working temperature of not less than 100 °C. In addition, the requirements of Pt B, Ch 1, Sec 1, [5.3.2] are to be complied with • Reference is to be made to (2)	Flexible hoses shall comply with the following requirements: • They shall be made of material suitable to be used for the intended service and capable of maintaining their integrity at a maximum working temperature of not less than 100 °C. In addition, the requirements of Pt B, Ch 1, Sec 1, [5.3.2] are to be complied with • Reference is to be made to (2)
Bilge system	Flexible hoses shall comply with the following requirements: • They shall be made of material suitable to be used for the intended service and capable of maintaining their integrity at a maximum working temperature of not less than 100 °C. In addition, the requirements of Pt B, Ch 1, Sec 1, [5.3.2] are to be complied with • In any case, the flexible hose is to be certified suitable for use by the manufacturer •Reference is to be made to (2)	Flexible hoses shall comply with the following requirements: • flexible hoses built in PVC reinforced with embedded steel wire and additional fiber reinforcement or equivalent can be accepted. In any case, the flexible hose is to be certified suitable for use by the manufacturer • In addition, the requirements of Pt B, Ch 1, Sec 1, [5.3.2] are to be complied with •Reference is to be made to (2)

Requirements for each service and locations (1)		
System	Machinery space or other spaces with fire risk	Spaces without fire risk
Cooling system	Flexible hoses shall comply with the following requirements: • with the exclusion of the part of piping indicated in Pt B, Ch 1, Sec 1, [5.3.2], flexible hoses can be accepted in compliance with ISO 13363 or equivalent, and certified suitable for use by the manufacturer in compliance with national or international recognized standards. • Reference is to be made to (2)	Flexible hoses shall comply with the following requirements: • with the exclusion of the part of piping indicated in Pt B, Ch 1, Sec 1, [5.3.2], flexible hoses can be accepted in compliance with ISO 13363 or equivalent, and certified suitable for use by the manufacturer in compliance with national or international recognized standards. • Reference is to be made to (2)
Scupper pipe	Flexible hoses shall comply with the following requirements: • with the exclusion of the part of piping indicated in Pt B, Ch 1, Sec 1, [5.3.2], flexible hoses made of material suitable to be used for this service, and capable of maintaining their integrity at a maximum working temperature of not less than 100 °C can be accepted. • Reference is to be made to (2)	Flexible hoses shall comply with the following requirements: • Pt B, Ch 1, Sec 1, [5.3.2], flexible hoses built in PVC reinforced with embedded steel wire and additional fiber reinforcement or equivalent can be accepted. • In any case, the flexible hose is to be certified suitable for use by the manufacturer. • Reference is to be made to (2)
Exhaust system	The requirements of Pt B, Ch 1, Sec 1, [5.3.3] are to be complied with.	The requirements of Pt B, Ch 1, Sec 1, [5.3.3] are to be complied with.
Drinking water, black water and drainage of air-conditioning systems	Metallic hoses, flexible hoses. Flexible hoses shall comply with the following requirements • Any parts connected to the external discharge through the side of the hull shall comply with the requirements for the scuppers. • In any case, the flexible hose is to be certified suitable for use by the manufacturer. • Reference is to be made to (2)	Metallic hoses, flexible hoses. Flexible hoses shall comply with the following requirements • Any parts connected to the external discharge through the side of the hull shall comply with the requirements for the scuppers. • In any case, the flexible hose is to be certified suitable for use by the manufacturer. • Reference is to be made to (2)
(1) End connections different from the crimped type may be adopted only for Class III piping **(2)** All systems provided with external discharge through the side of the hull are to be fitted with a metallic valve on the side of the hull. a) The above valve may be omitted provided that: • for non-sailing yachts, the side discharge is positioned at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel more than 7°, whichever is greater; • for sailing yachts, the sea discharge is positioned at a point corresponding to an angle more than 30° or more than the angle corresponding to the intersection of the deck with the side, whichever is the lesser; • for non-sailing yachts, a metallic branch or a branch of material equivalent to that of the hull (i.e. GRP) is fitted from the passage through the hull at a point 300 mm above the maximum waterline or a point corresponding to an angle of heel of 7°, whichever is the greater. b) In any case, an adequate non-return valve is to be fitted where it is ascertained that under operating conditions the yacht may assume an angle of heel for which the ingress of water cannot be avoided. c) Where joints are provided between the metallic branch and non-metallic pipe, they are to be adequate for the purpose. If joints with clamps are fitted, they are to be made of stainless steel. At least two clamps are to be fitted for each joint end. In general, the clamps are to be no less than 12 mm in width and are not to be dependent on spring tension to remain fastened.		

4.2 Scuppers and Sanitary discharges

4.2.1 What required in Sec 10, [8] may be applied as far as it is practicable and taking into account Tab 1.

4.3 Air pipes, sounding and overflow pipes

4.3.1 What required in Sec 10, [9] may be applied as far as it is practicable in terms of minimum sections, minimum thicknesses and closing appliances for air pipes.

4.4 Fuel oil System

4.4.1 What required in Sec 10, [11] may be applied as far as it is practicable and taking into account Tab 1.

4.5 Lubricating oil System

4.5.1 What required in Sec 10, [12] may be applied as far as it is practicable and taking into account Tab 1.

4.6 Hydraulic oil System

4.6.1 What required in Sec 10, [13] may be applied as far as it is practicable and taking into account Tab 1.

4.7 Compressed air System

4.7.1 What required in Sec 10, [14] may be applied as far as it is practicable.

4.8 Exhaust gas System

4.8.1 What required in Sec 10, [15] may be applied as far as it is practicable and taking into account Tab 1.

4.9 Certification, Inspection and Testing on Piping

4.9.1 What required in Sec 10, [17] may be applied as far as it is practicable and relaxations may be agreed with the Society.

5 Steering (Sec 5)

5.1 General

5.1.1 Hydraulic steering gears certified as compliant with ISO 10592 are required to also comply with the non-conflicting requirements in Sec 11. Electric and electronic steering gears and control systems (including electric and electronic control systems of hydraulic steering gears) certified as compliant with ISO 25197 are required to also comply with the non-conflicting requirements in Sec 11.

APPENDIX 3 PLASTIC PIPES

1 General

1.1 Application

1.1.1 These requirements are applicable to all piping systems with parts made of rigid plastic or with parts made predominantly of other material than metal.

1.1.2 Piping systems made of thermoplastic materials, such as polyethylene(PE), polypropylene(PP), and polybutylene (PB), and intended for non-essential services are to meet the requirements of recognised standards as well as [2.1.2], [2.3.4], [2.4.2], [3] and [4].

1.1.3 The use of mechanical joints approved for the use in metallic piping systems only are not permitted.

1.2 Use of plastic pipes

1.2.1 Plastic may be used in piping systems in accordance with the provisions of Sec 9, [2.1.3], provided the following requirements are complied with.

1.2.2 Plastic pipes are to be type approved by Tasneef.

1.3 Definitions

1.3.1 Plastic

Plastic includes both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and FRP (reinforced plastic pipes).

1.3.2 Piping systems

Piping systems mean those made of plastic and include the pipes, fittings, joints, and any internal or external liners, coverings and coatings required to comply with the performance criteria.

1.3.3 Joints

Joints include all pipe assembling devices or methods, such as adhesive bonding, laminating, welding, etc.

1.3.4 Fittings

Fittings include bends, elbows, fabricated branch pieces, etc made of plastic materials.

1.3.5 Nominal pressure

Nominal pressure is the maximum permissible working pressure, which is to be determined in accordance with [2.2.2]

1.3.6 Design pressure

Design pressure is the maximum working pressure which is expected under operating conditions or the highest set pressure of any safety valve or pressure relief device on the system, if fitted.

1.3.7 Fire endurance

Fire endurance is the capability of the piping system to perform its intended function, i.e. maintain its strength and integrity, for some predicted period of time while exposed to fire.

1.3.8 Essential to the safety of yacht

Essential to the safety of ship means all piping systems that in event of failure will pose a threat to personnel and the yacht (see as example the systems reported in Tab 1)

1.3.9 Essential services

Essential services are those services essential for propulsion and steering and safety of the yacht as specified in Ch 2, Sec 1, [3].

2 Design of plastic piping systems

2.1 General

2.1.1 Specification

The specification of the plastic piping is to be submitted in accordance with the provisions of Sec 10, [1.2.2]. It is to comply with a recognised national or international standard approved by the Society. In addition, the requirements stated below are to be complied with.

2.1.2 Marking

Plastic pipes and fittings are to be permanently marked with identification, including:

- pressure ratings
- the design standards that the pipe or fitting is manufactured in accordance with
- the material of which the pipe or fitting is made.

2.2 Strength

2.2.1 General

a) The piping is to have sufficient strength to take account of the most severe concomitant conditions of pressure, temperature, the weight of the piping itself and any static and dynamic loads imposed by the design or environment.

b) The maximum permissible working pressure is to be specified with due regard for the maximum possible working temperature in accordance with the Manufacturer's recommendations.

2.2.2 Permissible pressure

Piping systems are to be designed for a nominal pressure determined from the following conditions:

a) Internal pressure

The nominal internal pressure is not to exceed the smaller of:

- $P_{sth}/4$
- $P_{lth}/2,5$

where:

P_{sth} : Short-term hydrostatic test failure pressure, in MPa

P_{lth} : Long-term hydrostatic test failure pressure (>100 000 hours), in MPa.

b) External pressure (to be considered for any installation subject to vacuum conditions inside the pipe or a head of liquid acting on the outside of the pipe)

The nominal external pressure is not to exceed $P_{col}/3$, where:

P_{col} : Collapse pressure

Note 1: The external pressure is the sum of the vacuum inside the pipe and the static pressure head outside the pipe.

The collapse pressure is not to be less than 0,3 MPa.

c) c) Notwithstanding the requirements of a) or b) as applicable, the pipe or pipe layer minimum wall thickness is to follow recognized standards. In the absence of standards for pipes not subject to external pressure, the requirements of b) are to be met.

2.2.3 Permissible temperature

a) In general, plastic pipes are not to be used for media with a temperature above 60°C or below 0°C, unless satisfactory justification is provided to Tasneef.

b) The permissible working temperature range depends on the working pressure and is to be in accordance with the Manufacturer's recommendations.

c) The maximum permissible working temperature is to be at least 20°C lower than the minimum heat distortion temperature of the pipe material, determined according to ISO 75 method A or equivalent e.g. ASTMD648-18.

d) The minimum heat distortion temperature is not to be less than 80°C.

2.2.4 Axial strength

a) The sum of the longitudinal stresses due to pressure, weight and other loads is not to exceed the allowable stress in the longitudinal direction.

b) In the case of fibre reinforced plastic pipes, the sum of the longitudinal stresses is not to exceed half of the nominal circumferential stress derived from the nominal internal pressure condition (see [2.2.2]).

2.2.5 Impact resistance

Plastic pipes and joints are to have a minimum resistance to impact in accordance with a recognised national or international standard.

2.3 Requirements depending on service and/or location

2.3.1 Fire endurance

The requirements for fire endurance of plastic pipes and their associated fittings are given in Tab 1 for the various systems and locations where the pipes are used.

Specifically:

- a 60 min fire endurance test in dry conditions is to be carried out according to Appendix 1 of IMO Resolution A.753(18) as amended by IMO Resolutions MSC. 313(88) and MSC. 399(95), where indicated "L1" in Tab 1
- Level 1W - Piping systems similar to Level 1 systems except these systems do not carry flammable fluid or any gas and a maximum 5% flow loss in the system after exposure is acceptable (L1W)
- a 30 min fire endurance test in dry conditions is to be carried out according to Appendix 1 of IMO Resolution A.753(18) as amended by IMO Resolutions MSC. 313(88) and MSC. 399(95), where indicated "L2" in Tab 1
- o Level 2W - Piping systems similar to Level 2 systems except a maximum 5% flow loss in the system after exposure is acceptable (L2W)
- a 30 min fire endurance test in wet conditions is to be carried out according to Appendix 2 of IMO Resolution A.753(18) as amend-ed by IMO Resolutions MSC.313(88) and MSC.399(95), where indicated "L3" in Tab 1
- no fire endurance test is required where “0” is indicated in Tab 1
- a metallic material with a melting point greater than 925°C is to be used where “X” is indicated in Tab 1.

Note 1: “NA” means “not applicable”.

Unless instructed otherwise by the Flag Administration, fire endurance tests are to be carried out with specimen representative for pipes, joints and fittings:

Note 2: “A test specimen incorporating several components of a piping system may be tested in a single test.

a) Pipes.

   - for sizes with outer diameter < 200 mm the minimum outer diameter and wall thickness

   Note 3: Test conditions are most demanding for minimum wall thickness and thus larger wall thickness is covered. A key factor determining the fire per-formance of a pipe component variant is the thickness-to-diameter (t/D) ratioi and whether it is larger or smaller than that of the variant which has been fire-tested. If fire-protective coatings or layers are included in the variant used in the fire test, only variants with the same or greater thickness of pro-tection, regardless of the (t/D) ratio, are to be qualified by the fire test.

   - for sizes with outer diameter >= 200 mm one test specimen for each category of t/d (D = outer diameter, t = structural wall thickness). A scattering of ± 10% for t/D is regarded as the same group.

   Minimum size approved is equal to the diameter of specimen successfully tested.

b) Joints.

   - each type of joint applicable for applied fire endurance level tested on pipe to pipe specimen.

   Means are to be provided to ensure a constant media pressure inside the test specimen during the fire test as specified in Appendix 1 or 2 of the IMO Res.A.753(18), as amended by IMO Resolutions MSC.313(88) and MSC.399(95). During the test it is not permitted to replace media drained by fresh water or nitrogen.

2.3.2 Flame spread

a) a) All pipes, except those fitted on open decks and within tanks, cofferdams, pipe tunnels and ducts if separated from accommoda-tion, permanent manned areas and escape ways by means of an A class bulkhead are to have low spread characteristics not ex-ceeding average values listed in Appendix 3 of IMO Resolution 753(18), as amended by IMO Resolutions MSC. 313(88) and MSC. 399(95)..

b) b) Surface flame characteristics are to be determined using the procedure given in the 2010 FTP Code, Annex 1, Part 5 with regard to the modifications due to the curvilinear pipe surfaces as also listed in Appendix 3 of Resolution A.753(18) as amended by IMO Res-olutions MSC. 313(88) and MSC. 399(95)..

c) c) Surface flame spread characteristics may also be deter-mined using the test procedures given in ASTM D635-18, or other national equivalent standards. Under the procedure of ASTM D635-18 a maximum burning rate of 60 mm/min applies. In case of adoption of other national equivalent standards, the relevant acceptance criteria are to be defined..

2.3.3 Fire protection coating

Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance level required, it is to meet the following requirements:

- The pipes are generally to be delivered by the Manufacturer with the protective coating on.
- The fire protection properties of the coating are not to be diminished when exposed to salt water, oil or bilge slops. It is to be demonstrated that the coating is resistant to products likely to come into contact with the piping.
- In considering fire protection coatings, such characteristics as thermal expansion, resistance against vibrations and elasticity are to be taken into account.
- The fire protection coatings are to have sufficient resistance to impact to retain their integrity.

2.3.4 Electrical conductivity

a) Piping systems conveying fluids with a conductivity less than 1000 pS/m (1pS/m=10^{-12} siemens per metre), such as refined products and distillates, are to be made of conductive pipes.

b) Regardless of the fluid to be conveyed, plastic pipes passing through hazardous areas are to be electrically conductive.

c) Where electrical conductivity is to be ensured, the resistance of the pipes and fittings is not to exceed:

   1 x 10^5 Ohm/m.

d) It is preferred that pipes and fittings are homogeneously conductive. Where pipes and fittings are not homogeneously conductive, conductive layers are to be provided, suitably protected against the possibility of spark damage to the pipe wall.

e) Satisfactory earthing is to be provided.

2.4 Pipe and fitting connections

2.4.1 General

a) The strength of connections is not to be less than that of the piping system in which they are installed.

b) Pipes and fittings may be assembled using adhesive-bonded, welded, flanged or other joints.

c) When used for joint assembly, adhesives are to be suitable for providing a permanent seal between the pipes and fittings throughout the temperature and pressure range of the intended application.

d) Tightening of joints, where required, is to be performed in accordance with the Manufacturer's instructions.

e) Procedures adopted for pipe and fitting connections are to be submitted to the Society for approval, prior to commencing the work.

Table 1 : Fire endurance of piping systems

PIPING SYSTEM	LOCATION						
	Machinery spaces of category A (5)	Other machinery spaces (6)	Fuel oil tanks (7)	Ballast water tanks (8)	Cofferdams, void spaces, pipe tunnels and ducts(9)	Accommodation, service and control spaces (10)	Open decks (11)
FLAMMABLE LIQUIDS (FLASHPOINT > 60°C)							
Fuel oil	X	X	0	0	0	L1	L1
Lubricating oil	X	X	NA	NA	0	L1	L1
Hydraulic oil	X	X	0	0	0	L1	L1
SEA WATER (1)							
Bilge main and branches	L1	L1	0	0	0	NA	L1
Fire main and water spray	L1	L1	NA	0	0	X	L1
Foam system	L1W	L1W	NA	NA	0	L1W	L1W
Sprinkler system	L1W	L1W	NA	0	0	L3	L3
Ballast	L3	L3	0	0	0	L2W	L2W

PIPING SYSTEM	LOCATION						
	Machinery spaces of category A (5)	Other machinery spaces (6)	Fuel oil tanks (7)	Ballast water tanks (8)	Cofferdams, void spaces, pipe tunnels and ducts(9)	Accommodation, service and control spaces (10)	Open decks (11)
Cooling water, essential services	L3	L3	NA	0	0	NA	L2W
Tank cleaning services, fixed machines	NA	NA	NA	0	0	NA	L3
Non-essential systems	0	0	0	0	0	0	0
FRESH WATER							
Cooling water, essential services	L3	L3	0	0	0	L3	L3
Non-essential systems	0	0	0	0	0	0	0
SANITARY, DRAINS, SCUPPERS							
Deck drains (internal)	L1W **(2)**	L1W **(2)**	0	0	0	0	0
Sanitary drains (internal)	0	0	0	0	0	0	0
Scuppers and discharges (overboard): Fitted above heaviest water level	X **(1)**	X **(1)**	0	0	0	X **(1)**	0
Scuppers and discharges (overboard): Fitted below heaviest water level	X	X	0	0	0	X	X
SOUNDING, AIR							
Water tanks, dry spaces	0	0	0	0	0	0	0
Oil tanks (flashpoint > 60°C)	X	X	0	0	0	X	X
MISCELLANEOUS							
Control air	L1 **(3)**	L1 **(3)**	0	0	0	L1 **(3)**	L1 **(3)**
Service air (non-essential)	0	0	0	0	0	0	0
Brine	0	0	NA	NA	0	0	0

PIPING SYSTEM	LOCATION						
	Machinery spaces of category A (5)	Other machinery spaces (6)	Fuel oil tanks (7)	Ballast water tanks (8)	Cofferdams, void spaces, pipe tunnels and ducts(9)	Accommodation, service and control spaces (10)	Open decks (11)
Urea transfer/supply system (SCR installations)	X(13)	X (13)	NA	NA	NA	L3(12)	0

(1) For scuppers and draining coming from the open deck, X may be replaced by 0 if a remote control valve is to be fitted at vessel side, and suitable means are to be provided to blank the intake opening on deck . The valve is to be controlled from outside space and at the upper end with a means of closing capable of being operated from a position above the free-board deck in order to prevent downflooding.
(2) For drains serving only the space concerned, "0" may replace "L1W".
(3) When controlling functions are not required by the Rules, "0" may replace "L1".
(4) Machinery spaces of category A are defined in Sec 1, [1.3.1].
(5) Spaces, other than category A machinery spaces containing propulsion machinery and internal combustion engines, generators and major electrical machinery, pumps, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces
(6) Empty spaces between two bulkheads separating two adjacent compartments.
(7) All spaces used for fuel oil and trunks to such spaces.
(8) All spaces used for ballast water and trunks to such spaces.
(9) Empty spaces between two bulkheads separating two adjacent compartments.
(10) Accommodation spaces, service spaces and control stations are defined in Ch 4, Sec 1, [1].
(11) Open decks are defined in Ch 4, Sec 1, [1].
(12) L3 in service spaces, NA in accommodation and control spaces.
(13) Type Approved plastic piping without fire endurance test (0) is acceptable downstream of the tank valve, provided this valve is metal seated and arranged as fail-to-closed or with quick closing from a safe position outside the space in the event of fire.

2.4.2 Bonding of pipes and fittings

a) The procedure for making bonds is to be submitted to Tasneef for qualification. It is to include the following:
- materials used
- tools and fixtures
- joint preparation requirements
- cure temperature
- dimensional requirements and tolerances
- acceptance criteria for the test of the completed assembly.

b) When a change in the bonding procedure may affect the physical and mechanical properties of the joints, the procedure is to be requalified.

3 Arrangement and installation of plastic pipes

3.1 General

3.1.1 Plastic pipes and fittings are to be installed in accordance with the Manufacturer's guidelines.

3.2 Supporting of the pipes

3.2.1

a) Selection and spacing of pipe supports in board systems are to be determined as a function of allowable stresses and maximum deflection criteria.

b) The selection and spacing of pipe supports are to take into account the following data:
- pipe dimensions
- mechanical and physical properties of the pipe material
- mass of pipe and contained fluid
- external pressure

- operating temperature
- thermal expansion effects
- load due to external forces
- thrust forces
- water hammer
- vibrations
- maximum accelerations to which the system may be subjected.

Combinations of loads are also to be considered.

c) Support spacing is not to be greater than the pipe Manufacturer's recommended spacing.

3.2.2 Each support is to evenly distribute the load of the pipe and its content over the full width of the support. Measures are to be taken to minimise wear of the pipes where they are in contact with the supports.

3.2.3 Heavy components in the piping system such as valves and expansion joints are to be independently supported.

3.3 Provision for expansion

3.3.1 Suitable provision is to be made in each pipeline to allow for relative movement between pipes made of plastic and the steel structure, having due regard to:

- the high difference in the coefficients of thermal expansion
- deformations of the 's structure.

3.3.2 Calculations of the thermal expansions are to take into account the system working temperature and the temperature at which the assembly is performed.

3.4 External loads

3.4.1 When installing the piping, allowance is to be made for temporary point loads, where applicable. Such allowance is to include at least the force exerted by a load (person) of 100 kg at mid-span on any pipe of more than 100 mm nominal outside diameter.

3.4.2 Pipes are to be protected from mechanical damage where necessary.

3.4.3 As well as providing adequate robustness for all piping, including open-ended piping, the minimum wall thickness complying with [2.2.2] a) may be increased at the request of Tasneef taking into account the conditions encountered during service on board vessels.

3.5 Earthing

3.5.1 Where, in pursuance of [2.3.4], pipes are required to be electrically conductive, the resistance to earth from any point in the piping system is not to exceed 1×10^6 ohm.

3.5.2 Where provided, earthing wires are to be accessible for inspection.

3.6 Penetration of fire divisions and watertight bulkheads or decks

3.6.1 Where plastic pipes pass through "A" or "B" class divisions, arrangements are to be made to ensure that fire endurance is not impaired. These arrangements are to be tested in accordance with "Recommendations for Fire Test Procedures for "A", "B" and "F" Bulkheads" specified in Part 3 of Annex 1 to the 2010 FTP Code.

3.6.2

When plastic pipes pass through watertight bulkheads or decks, the watertight integrity of the bulkhead or deck is to be maintained. For pipes not able to satisfy the requirements in [2.2.2] b), a metallic shut-off valve operable from above the freeboard deck should be fitted at the bulkhead or deck. This valve may be omitted if the penetration is fitted at a distance more than B/3 from the sides and above the design waterline, or somehow protected with watertight divisions from minor hull damages. If the bulkhead or deck is also a fire division and destruction by fire of plastic pipes may cause the inflow of liquid from tanks, a metallic shut-off valve operable from above the freeboard deck is to be fitted at the bulkhead or deck.

3.7 Systems connected to the hull

3.7.1 Bilge and sea water systems

a) Where, in pursuance of [2.3.1], plastic pipes are permitted in bilge and sea water systems, the side valves required in Sec 10, [2.8] and, where provided, the connecting pipes to the shell are to be made of metal in accordance with Sec 10, [2.1].

b) Vessel side valves are to be provided with remote control from outside the space concerned, see Tab 1, footnote **(1)**.

3.7.2 Scuppers and sanitary discharges

a) Where, in pursuance of [2.3.1], plastic pipes are permitted in scuppers and sanitary discharge systems connected to the shell, their upper end is to be fitted with closing means operated from a position above the freeboard deck in order to prevent downflooding, see Tab 1, footnotes **(1)**.

b) Discharge valves are to be provided with remote control from outside the space concerned.

3.8 Application of fire protection coatings

3.8.1 Where necessary for the required fire endurance as stated in [2.3.3], fire protection coatings are to be applied on the joints, after performing hydrostatic pressure tests of the piping system.

3.8.2 The fire protection coatings are to be applied in accordance with the Manufacturer's recommendations, using a procedure approved in each case.

4 Certification, inspection and testing of plastic piping

4.1 Certification

4.1.1 Type approval

Plastic pipes, fittings, joints and any internal or external liners, coverings and coatings are to be of a type approved by the Society for the intended use according to the Rules for Type Approval of Plastic Pipes.

4.1.2 Bonding qualification test

a) A test assembly is to be fabricated in accordance with the procedure to be qualified. It is to consist of at least one pipe-to-pipe joint and one pipe-to-fitting joint.

b) When the test assembly has been cured, it is to be subjected to a hydrostatic test pressure at a safety factor of 2,5 times the design pressure of the test assembly, for not less than one hour. No leakage or separation of joints is allowed. The test is to be conducted so that the joint is loaded in both longitudinal and circumferential directions.

c) Selection of the pipes used for the test assembly is to be in accordance with the following:
   - when the largest size to be joined is 200 mm nominal outside diameter or smaller, the test assembly is to be the largest piping size to be joined.
   - when the largest size to be joined is greater than 200 mm nominal outside diameter, the size of the test assembly is to be either 200 mm or 25% of the largest piping size to be joined, whichever is the greater.

4.2 Workshop tests

4.2.1 Each pipe and fitting is to be tested by the Manufacturer at a hydrostatic pressure not less than 1,5 times the nominal pressure. Alternatively, for pipes and fittings not employing hand lay-up techniques, the hydrostatic pressure test may be carried out in accordance with the hydrostatic testing requirements stipulated in the recognised national or international standard to which the pipes or fittings are manufactured, provided that there is an effective quality system in place.

4.2.2 The Manufacturer is to have quality system that meets ISO 9000 series standards or equivalent.

The quality system is to consist of elements necessary to ensure that pipes and fittings are produced with consistent and uniform mechanical and physical properties.

4.2.3 IIn case the manufacturer does not have an approved quality system complying with ISO 9001:2015 or equivalent, pipes and fittings are to be tested in accordance with these requirements to the Surveyor's satisfaction for every batch of pipes.

4.2.4 Depending upon the intended application, the Society may require the pressure testing of each pipe and/or fitting.

4.3 Testing after installation on board

4.3.1 Hydrostatic testing

a) Piping systems for essential systems are to be subjected to a test pressure of not less than 1,5 times the design pressure or 0,4 MPa, whichever is the greater.

b) Piping systems for non-essential services are to be checked for leakage under operational conditions.

4.3.2 Earthing test

For piping required to be electrically conductive, earthing is to be checked and random resistance testing is to be performed.

APPENDIX 4 INSTALLATION OF BALLAST WATER MANAGEMENT SYSTEMS

1 Application

1.1

1.1.1

In addition to the requirements contained in Sec 10, [7] and in Ch 4, Sec 1, [10], the following is to be complied with, when a Ballast wa-ter Management system is installed on board

The requirement herewith are additional to the requirements contained in BWM Convention (2004).

In this Section requirements for BWMS of category 1 and 2 as below defined are included.

Category 1:

In-line UV or UV + Advanced Oxidation Technology (AOT) or UV + TiO2 or UV + Plasma

See Figure 1

Category 2:

In-line Flocculation

See Figure 2

For the installation of BWMS different to those above reference is to be made to Pt C, Ch 1, App 8 and Chapter 4 as applicable of Tasneef Rules for the Classification of Ships.

Figure 1 : BWMS Technology Group no.1 In-line UV including UV+AOT Including UV+TiO2

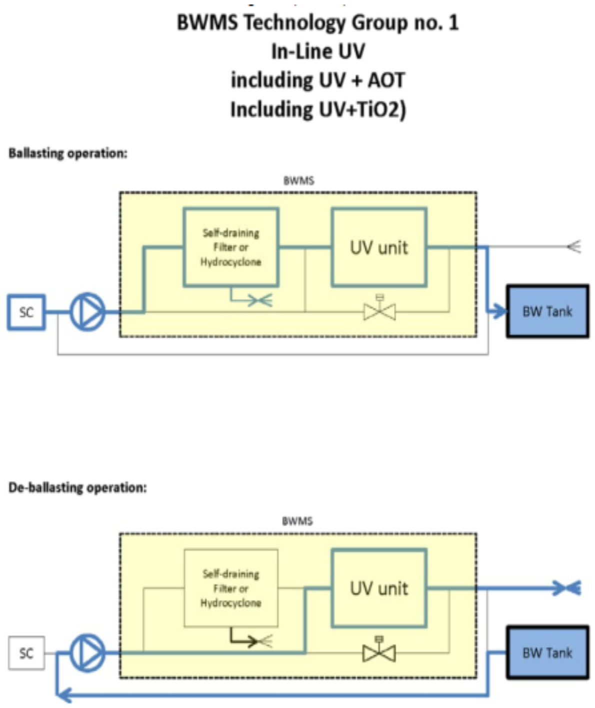
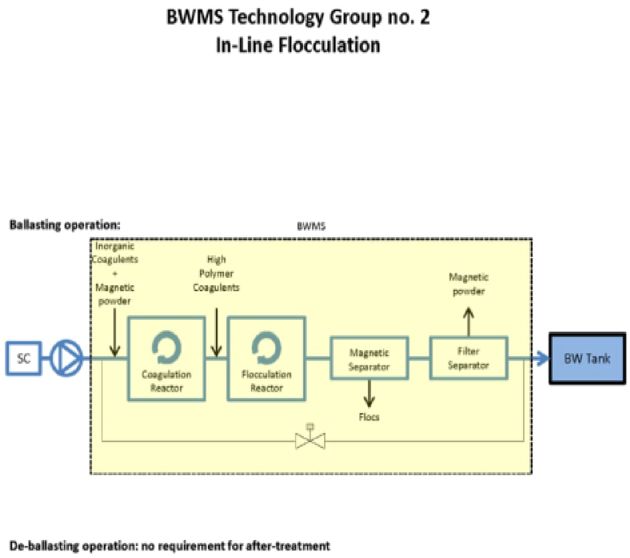


Figure 2 : BWMS Technology Group no.2 In-line Flocculation



2 Definitions

2.1

2.1.1

Ballast Water Management System (hereinafter referred to as 'BWMS') means any system which processes ballast water such that it meets or exceeds the Ballast Water Performance Standard in Regulation D-2 of the BWM Convention. The BWMS includes ballast water equipment, all associated piping arrangements as specified by the manufacturer, control and monitoring equipment and sampling facilities. The categorization of BWMS technologies is given in Tab 1. Applicability of the requirements for each BWMS technology is in accordance with Tab 2.

2.1.2

Dangerous gas means any gas which may develop an atmosphere being hazardous to the crew and/or the due to flammability, explosivity, toxicity, asphyxiation, corrosivity or reactivity and for which due consideration of the hazards is required, e.g. hydrogen (H_2), hydrocarbon gas, oxygen (O2), carbon dioxide (CO2), carbon monoxide (CO), ozone (O_3), chlorine (Cl_1) and chlorine dioxide (ClO_2), etc.

2.1.3

Hazardous area is defined in IEC 60092-502:1999 and means an area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus. When a gas atmosphere is present, the following hazards may also be present: toxicity, asphyxiation, corrosivity and reactivity.

2.1.4

Dangerous liquid means any liquid that is identified as hazardous in the Material Safety Data Sheet or other documentation relating to this liquid.

2.1.5

Non-hazardous area means an area which is not a hazardous area as defined in above [2.1.3].

Table 1 : Categorization of BWMS technologies

BWMS,s Technology category* (informative in [5] should be referred to)®		1	2	3a	3b	3c	4	5	6	7a	7b	8
Characteristics		In-line UV or UV + Advanced Oxidation Technology (AOT) or UV + TiO2 or UV + Plasma	In-line Flocculation	In-line membrane separation and de-oxygenation (injection of N2 from a N2 Generator)	In-line de-oxygenation (injection of Inert Gas from Inert Gas Generator)	In-tank de-oxygenation with Inert Gas Generator	In-line full flow electrolysis	In-line side stream electrolysis (2)	In-line (stored) chemical injection	In-line side-stream ozone injection without gas/liquid separation tank and without Discharge treatment tank	In-line side-stream ozone injection with gas/liquid separation tank and Discharge water treatment tank	In-tank pasteurization and de-oxygenation with N2 generator
Des-infection when ballasting	Making use of active substance		X			In-tank technology: No treatment when ballasting or de-ballasting	X	X	X	X	X	In-tank technology: No treatment when ballasting or de-ballasting
	Full flow of ballast water is passing through the BWMS	X	X	X	X		X				X	
	Only a small part of ballast water is passing through the BWMS to generate the active substance							X				
After-treatment when de-ballasting	Full flow of ballast water is passing through the BWMS	X									X	
	Injection of neutralizer						X	X	X	X	X	
	Not required by the Type Approval Certificate issued by the Administration		X	X								
Examples of dangerous gas as defined in [2.1.3]			(1)	O2 N2	CO2 CO		H2 Cl2	H2 Cl2	(1)	O2 O3 N2		O2 N2

Notes:

(1) To be investigated on a case by case basis based on the result of the IMO (GESAMP) MEPC report for Basic and Final approval in accordance with the G9 Guideline.

(2) In-line side stream electrolysis may also be applied in-tank in circulation mode (no treatment when ballasting or de-ballasting).

* Taking into consideration future developments of BWMS technologies, some additional technologies may be considered in this Table by identifying their characteristics in the same manner as for the above BWMS cat.1, 2, 3a, 3b, 3c, 4, 5, 6, 7a, 7b and 8.

Table 2 : Applicability of the requirements for each BWMS technology

BWMS,s Technology category (informative in [5] should be referred to)®	1	2	3a	3b	3c	4	5	6	7a	7b	8
Requirement ¯	In-line UV or UV + Advanced Oxidation Technology (AOT) or UV + TiO2 or UV + Plasma	In-line Flocculation	In-line membrane separation and de-oxygenation (injection of N2 from a N2 Generator)	In-line de-oxygenation (injection of Inert Gas from Inert Gas Generator)	In-tank de-oxygenation with Inert Gas Generator	In-line full flow electrolysis	In-line side stream electrolysis (2)	In-line (stored) chemical injection	In-line side-stream ozone injection without gas/liquid separation tank and without Discharge treatment tank	In-line side-stream ozone injection with gas/liquid separation tank and Discharge water treatment tank	In-tank pasteurization and de-oxygenation with N2 generator
[1] and [2]	X	X	X	X	X	X	X	X	X	X	X
[3.1.1] to [3.1.4]	X	X	X	X	X	X	X	X	X	X	X
[3.1.5]			X	X	X						X
[3.1.6]	X	X	X	X	X	X	X	X	X	X	X
[3.1.7]			X	X	X						X
[3.1.8]				X						X	
[3.1.9]	X	X	X	X	X	X	X	X	X	X	X
[3.2.1], a)				X	X				X	X	
[3.2.1], b)						X	X	X			
[3.2.2]	X	X	X	X		X	X	X	X	X	
[3.2.3]	X	X	X	X	X	X	X	X	X	X	X
[3.2.4]	X	X	X	X		X	X	X	X	X	
[3.3.1], a)		X	X			X	X	X	X	X	X
[3.3.1], b)			X	X	X				X	X	X
[3.3.1], c)									X	X	
[3.3.1], d)						X	X	X	X	X	
[3.3.1], e)						X	X	X			
[3.3.1], f)			X	X	X				X	X	X
[3.3.2], a) to [3.3.2], d)		X	X	X	X	X	X	X	X	X	X
[3.3.2], e)			X			X	X	X	X	X	X
[3.3.2], f)			X						X	X	X
[3.3.2], g)			X			X	X	X	X	X	X
[3.3.3]		X				X	X	X	X	X	
[3.3.4]						X	X	X	X	X	

3 Installation

3.1 General requirements

3.1.1

All valves, piping fittings and flanges are to comply with the relevant requirements of IACS UR P2 and P4. In addition, special consideration can be given to the material used for this service with the agreement of Society.

3.1.2

The BWMS is to be provided with by-pass or override arrangement to effectively isolate it from any essential system to which it is connected. For new installation or retrofit to existing s, under normal operating conditions of ballasting and de-ballasting given in the Ballast Water Management Plan (BWMP) the adequacy of the generating plant capacity installed on the vessel is to be demonstrated by an electrical load analysis.

For retrofit installation to exiting s, a revised electrical load analysis with preferential trips of non-essential services can be accepted.

3.1.3

The BWMS is to be operated in accordance with the requirements specified in the Type Approval Certificate (TAC) issued by the Flag Administration. BWMS should be operated within its Treatment Rated Capacity (TRC) as per the TAC. This may require limiting of ’s ballast pump flowrates.

The arrangement of the bypasses or overrides of the BWMS is to be consistent with the approved Operation Maintenance and Safety Manual by the Flag Administration’s Type Approval.

In case the maximum capacity of the ballast pump(s) exceeds the maximum treatment rated Capacity (TRC) of the BWMS specified in the TAC issued by the Flag Administration, there should be a limitation on the BWMP giving a maximum allowable flow rate for operating the ballast pump(s) that is not to exceed the maximum TRC of the BWMS.

3.1.4

BWMS is to be subject to design review by the Society to verify the compliance of the BWMS’s manufacturer package with Sec 10, [1.1.1] a). Manufacturers of the BWMS may apply for this design review at the type approval process.

In general, monitoring functions of BWMS belongs to system category I under the application of Ch 3, Sec 3, Tab 1. However, in case a by-pass valve is integrated in the valve remote control system, the by-pass valve belongs to the system category II Ballast transfer remote control system.

The BWMS’s components are required to be inspected and certified by the Society at the manufactory (Society Certificate (SC) as defined in Sec 2, [1.5.4] including pressure vessels, piping class I or II, filters, switchboards, etc.

3.1.5

Electric and electronic components are not to be installed in a hazardous area unless they are of certified safe type for use in the area. Cable penetrations of decks and bulkheads are to be sealed when a pressure difference between the areas is to be maintained.

3.1.6

When it is required to have an automatic shutdown of the BWMS for safety reasons, this is to be initiated by a safety system independent of the BWM control system.

3.2 Special requirements for BWMS categories 2 generating dangerous gas or dealing with dangerous liquids.

3.2.1

Where the operating principle of the BWMS involves the generation of a dangerous gas, the following requirements are to be satisfied:

a) Gas detection equipment is to be fitted in the spaces where dangerous gas could be present, and an audible and visual alarm is to be activated both locally and at the BWMS control station in the event of leakage.

   The gas detectors should be located as close as possible to the BWMS components where the dangerous gas may accumulate.

   For flammable gases and explosive atmosphere including but not limited to H_2, the construction, testing and performance of the gas detection devices is to be in accordance with IEC 60079-29-1:2016, IEC 60079-29-2:2015, IEC 60079-29-3:2014 and/or IEC 60079-29-4:2009, as applicable.

Where other hazards are considered like toxicity, asphyxiation, corrosive and reactivity hazards, a recognized standard acceptable to the Society is to be selected with due consideration of the specific gases to be detected and due consideration of the performance of the detection device with regards to the specific atmosphere where it is used.

Chapter 2

ELECTRICAL INSTALLATIONS

SECTION 1 GENERAL

1 Application

1.1 General

1.1.1 The requirements of this Chapter apply to electrical installations on yachts. In particular, they apply to the components of electrical installations for:

- primary essential services
- secondary essential services
- services for habitability and air conditioning.

The other parts of the installation are to be so designed as not to introduce any risks or malfunctions to the above services.

1.2 References to other regulations and standards

1.2.1 The Society may refer to other regulations and standards when deemed necessary. These include the IEC publications, notably the IEC 60092 series and ISO standards.

1.2.2 When referred to by the Society, publications by the International Electrotechnical Commission (IEC) or other internationally recognised standards, are those currently in force at the date of agreement for classification.

2 Documentation to be submitted

2.1

2.1.1 The documents listed in Tab 1 are to be submitted.

The list of documents requested is to be intended as guidance for the complete set of information to be submitted, rather than an actual list of titles.

The Society reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

Unless otherwise agreed with the Society, documents for approval are to be sent in triplicate if submitted by the yard and in four copies if submitted by the equipment supplier.

Documents requested for information are to be sent in duplicate.

In any case, the Society reserves the right to require additional copies when deemed necessary.

2.1.2

In addition to the documentation listed in Tab 1, a FMEA, carried out according to the Tasneef "Guide for Failure mode and Effect Analysis" or other equivalent methods, and a Test Program, identifying the tests to be carried out in order to verify the assumptions and conclusions of the FMEA, may be requested for approval for the following systems where applicable (see Note 1):

- steering gear control system;
- electric propulsion control system;
- remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and/or explosion;

The FMEA may be requested by the Society for other systems on a case by case basis, depending on their influence on the overall safety.

Note 1: where the modes of failure and their consequences are clearly identifiable from the relevant drawings the Society may waive this request.

2.1.3

When an alteration or addition to an existing installation is proposed, updated plans are to be submitted for approval. As a minimum a technical specification, schematic diagrams and a proposed list of tests to be carried out onboard at the presence of the Tasneef Surveyor are to be included.

2.1.4

Where computer based systems are implemented and used to control the electrical installation, or to provide safety functions in accordance with the requirements of this Chapter (e.g. electric propulsion, steering gear, emergency safety systems etc.), the arrangements are to satisfy the applicable requirements of Chapter 3.

3 Definitions

3.1 General

3.1.1 Unless otherwise stated, the terms used in this Chapter have the definitions laid down by the IEC standards.

The definitions given in the following requirements also apply.

3.2 Essential services

3.2.1 Essential services are those services essential for propulsion and steering, and the safety of the , and services to ensure minimum comfortable conditions of habitability.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Documents to be submitted	Notes
GENERAL			
1	A	Single line diagram of main and emergency electric distribution systems.	The drawing is to include the single line diagram of: • the main switchboard and all the feeders connected to the main switchboard • the emergency switchboard and all feeders connected to the emergency switchboard • interconnector feeder between main switchboard and emergency switchboard • the main and emergency source of electrical power (i.e. generators and/or batteries and any additional source of power) • any distribution boards and motor control centers (MCC) • the main and emergency lighting distribution • transformers, converters and similar appliance which constitute an essential part of the electrical supply system • uninterruptible power system units (UPS) when providing an alternative power supply to essential services and/or when providing an alternative power supply or transitional power supply, if any, to the emergency services.
2	A	Electrical power balance (main and emergency supply including transitional source of emergency power, when required)..	The load balance of the main supply is to include the operating modes in which the yacht is intended to operate.
(1) A: to be submitted for approval I: to be submitted for information			

No.	I/A **(1)**	Documents to be submitted	Notes
3	I	Calculation of short-circuit currents for installation in which the sum of rated power of the energy sources which may be connected contemporaneously to the network is greater than 500 kVA.	The calculation is to include the short circuit currents at: • the main switchboard(s) • the emergency switchboard • all the distribution boards and MCC including those fed from transformers. Document is to include details of circuit breaker and fuse operating times and discrimination curves.
4	A	List of circuits including, for each supply and distribution circuit, data concerning the nominal current, the cable type, length and cross-section, nominal and setting values of the protective and control devices.	Main switchboard, emergency switchboards, each distribution board, motor control centers (MCC) and UPS and/or battery distribution.
5	A	Single line diagram and detailed wiring diagram of the main switchboard	
6	A	Single line diagram and detailed wiring diagram of the emergency switchboard.	
7	A	Single line diagram and detailed wiring diagram of the main distribution boards, and motor control centers.	Main distribution boards and motor control centers are intended as boards which are supplied directly or through transformer by main or emergency switchboard
8	A	Diagram and arrangement of the general emergency alarm system, the public address system and other intercommunication systems.	
9	A	A functional diagram of the distribution board specially reserved for the navigation lights.	
10	I	Schedule for recording of the type, location and maintenance cycle of batteries used for essential and emergency services.	Reference is to be made to the requirements of Sec 3, [11.1.1].
11	A	For electrical propulsion installations: -single line diagram of power distribution -single line diagram of control system and its power supply diagram, -wiring diagrams of power and control switchboards, -alarm and monitoring system technical specification, including list of alarms and monitoring points and its power supply diagram, -safety system including the list of monitored parameters and its power supply diagram.	For control alarm and safety system see Chapter 3.
12	A/I	For BATTERY POWERED yachts documents required by App 2, Tab 1 and for FUEL CELL POWERED yaht, documents required by App 3, Tab 1.	
13	A	A Single line diagram and a wiring diagram of the electric power circuits for steering gear	Reference is to be made to the requirements of Ch 1, Sec 11, [2.3], [2.4], [3] & [4]. For control alarm and safety system see Chapter 3
14	A	Electrical diagram of local application fixed gas fire-extinguishing systems.	Reference is to be made to the requirements of Ch 4, Sec 1, [7.1.2]
15	A	Electrical diagrams of power control and position indication circuits of watertight doors	
(1) A: to be submitted for approval I: to be submitted for information			

No.	I/A **(1)**	Documents to be submitted	Notes
16	I	General arrangement plan of the yacht showing location of main items of the electrical system	The plan is to include: • main switchboard(s) and emergency switchboard • main source of power including battery rooms, if any • emergency source of power and transitional source of power (where required by the applicable rules) • distribution boards supplying primary and secondary essential services • UPS or batteries serving primary and secondary essential services and emergency services • major equipment serving propulsion (e.g. motors, transformers, converter, etc.)
17	A	A functional diagram of uninterruptible power supply (UPS) for essential services, emergency services.	Reference is to be made to Sec 7, [3].
18	A	Plan of hazardous areas, where applicable	
19	A	Electrical diagram of the automatic fire detection and alarm systems and manually operated call points.	
20	A	Electrical diagram of the fixed gas fire-extinguishing systems.	
21	A	Electrical diagram of the sprinkler systems.	
22	A	Electrical diagram of power control and position indication circuits for fire doors.	
23	A	Diagram of the remote stop system (ventilation, fuel pumps, etc.).	
(1) A: to be submitted for approval I: to be submitted for information			

3.3 Primary essential services

3.3.1 *(1/1/2025)*

Primary essential services are those which need to be in continuous operation to maintain propulsion and steering.

Examples of equipment for primary essential services are the following:

- Steering gear
- Pumps for controllable pitch propellers
- Scavenging air blowers, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines and turbines necessary for the propulsion
- Azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps
- Electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps
- Electric generators and associated power sources supplying the above equipment
- Hydraulic pumps supplying the above equipment
- Control, monitoring and safety devices/systems for equipment for primary essential services
- Speed regulators dependent on electrical energy for main or auxiliary engines necessary for propulsion.

The main lighting system for those parts of the yacht normally accessible to and used by personnel and passengers is also considered (included as) a primary essential service.

3.4 Secondary essential services

3.4.1 *(1/1/2025)*

Secondary essential services are those services which need not necessarily be in continuous operation to maintain propulsion and steering but which are necessary for maintaining the vessel’s safety.

Examples of equipment for secondary essential services are the following:

- Windlasses

- Fuel oil transfer pumps and fuel oil treatment equipment
- Lubrication oil transfer pumps and lubrication oil treatment equipment
- Sea water pumps
- Starting air and control air compressors
- Bilge, ballast and heeling pumps
- Fire pumps and other fire-extinguishing medium pumps
- Ventilation fans for engine rooms
- Navigation lights, aids and signals
- Internal safety communication equipment
- Fire detection and alarm systems
- Electrical equipment for watertight closing appliances
- Electric generators and associated power supplying the above equipment
- Hydraulic pumps supplying the above equipment
- Control, monitoring and safety devices/systems for equipment for secondary essential services.

3.4.2 Services for habitability are those which need to be in operation to maintain the vessel's minimum comfort conditions for people on board.

Examples of equipment for maintaining conditions of habitability:

- Cooking
- Heating
- Domestic refrigeration
- Mechanical ventilation
- Sanitary and fresh water
- Electric generators and associated power sources supplying the above equipment.

3.5 Safety voltage

3.5.1 A voltage which does not exceed 50 V a.c. r.m.s. between conductors, or between any conductor and earth, in a circuit isolated from the supply by means such as a safety isolating transformer.

3.5.2 A voltage which does not exceed 50 V d.c. between conductors or between any conductor and earth in a circuit isolated from higher voltage circuits.

3.6 Low-voltage systems

3.6.1 Alternating current systems with rated voltages greater than 50 V r.m.s. up to 1000 V r.m.s. inclusive and direct current systems with a maximum instantaneous value of the voltage under rated operating conditions greater than 50 V up to 1500 V inclusive.

3.7 High-voltage systems

3.7.1 Alternating current systems with rated voltages greater than 1000 V r.m.s. and direct current systems with a maximum instantaneous value of the voltage under rated operating conditions greater than 1500 V.

3.8 Basic insulation

3.8.1 Insulation applied to live parts to provide basic protection against electric shock.

Note 1: Basic insulation does not necessarily include insulation used exclusively for functional purposes.

3.9 Supplementary insulation

3.9.1 Independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation.

3.10 Double insulation

3.10.1 Insulation comprising both basic insulation and supplementary insulation.

3.11 Reinforced insulation

3.11.1 A single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation.

Note 1: The term "single insulation system" does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

3.12 Earthing

3.12.1 The earth connection to the general mass of the hull of the yacht in such a manner as will ensure at all times an immediate discharge of electrical energy without danger.

3.13 Normal operational and habitable condition

3.13.1 A condition under which the yacht as a whole, the machinery, services, means and aids ensuring propulsion, ability to steer, safe navigation, fire and flooding safety, internal and external communications and signals, means of escape, and emergency boat winches, as well as the designed comfortable conditions of habitability are in working order and functioning normally.

3.14 Emergency condition

3.14.1 A condition under which any services needed for normal operational and habitable conditions are not in working order due to failure of the main source of electrical power.

3.15 Generating Set

3.15.1 An equipment or a set of equipment used to produce electrical power. The following are intended to be generating sets: diesel generator, shaft generator fully available even with yacht stationary, fuell cell, batteries bank.

3.16 Main source of electrical power

3.16.1 A source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the yacht in normal operational and habitable condition.

3.17 Dead ship condition

3.17.1 (1/1/2025)

The condition under which the main propulsion plant and auxiliaries are not in operation due to the absence of power.

Note 1: Dead ship condition is a condition in which the entire machinery installation, including the power supply, is out of operation and the 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.

3.18 Main generating station

3.18.1 The space in which the main source of electrical power is situated.

3.19 Main switchboard

3.19.1 A switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to the ’s services.

3.20 Emergency switchboard

3.20.1 A switchboard which in the event of failure of the main electrical power supply system is directly supplied by the emergency source of electrical power or the transitional source of emergency and is intended to distribute electrical energy to the emergency services.

3.21 Emergency source of electrical power

3.21.1 A source of electrical power, intended to supply the emergency switchboard in the event of failure of the supply from the main source of electrical power.

3.22 Distribution board

3.22.1

A switchgear and controlgear assembly which is supplied by the main or the emergency switchboard or distribution boards and is arranged for the distribution of electrical energy to other distribution boards, final distribution boards or final sub-circuits.

3.23 Final sub-circuit

3.23.1 That portion of a wiring system extending beyond the final required overcurrent protective device of a board.

3.24 Motor control centre (MCC)

3.24.1

A switchgear and controlgear assembly which is supplied by main or emergency switchboards and is intended to control and distribute electrical energy.

Note 1: It is possible for the MCC to be a section or sections of the main switchboard.

3.25 Hazardous areas

3.25.1 Areas in which an explosive atmosphere is present, or may be expected to be present due to the presence of vapours, gases, flammable dusts or explosives in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

3.25.2 Hazardous areas are classified in zones based upon the frequency and the duration of the occurrence of explosive atmosphere.

3.25.3

Hazardous areas for explosive gas atmosphere are classified in the following zones:

- Zone 0: an area in which ignitable concentrations of flammable gases or vapours are continuously present or present for long periods
- Zone 1: an area in which ignitable concentrations of flammable gases or vapours are likely to occur in normal operation
- Zone 2: an area in which ignitable concentrations of flammable gases or vapours are not likely to occur, or in which such a mixture, if it does occur, will exist for a short period only.

3.26 Certified safe-type equipment

3.26.1 Certified safe-type equipment is electrical equipment of a type for which a national or other appropriate authority has carried out the type verifications and tests necessary to certify the safety of the equipment with regard to explosion hazard when used in an explosive gas atmosphere.

3.27 Environmental categories

3.27.1

Electrical equipment is classified into environmental categories according to the temperature range, vibration levels, and resistance to chemically active substances and to humidity.

The designation of the environmental categories is indicated by the EC Code in Tab 3

The first characteristic numeral indicates the temperature range in which the electrical equipment operates satisfactorily, as specified in Tab 4

The second characteristic numeral indicates the vibration level in which the electrical equipment operates satisfactorily, as specified in Tab 5.

3.27.2 The tests for verifying the additional and supplementary letters and the characteristic numeral of the environmental categories are defined in Ch 3, Sec 6.

3.28 Navigation Light (NL)

3.28.1

Navigation Light (NL) means the following lights:

- masthead light, sidelights, sternlight, towing light, all-round light, flashing light as defined in Rule 21 of COLREGs (see Note 1),
- all-round flashing yellow light required for air-cushion vessels by Rule 23 of COLREGs,
- manoeuvring light required by Rule 34(b) of COLREGs.

Note 1:

COLREGs means Convention on the International Regulations for Preventing Collisions at Sea, 1972, including their annexes.

Table 2 : EC Code

Code letter	First characteristic numeral	Second characteristic numeral	Additional letter	Supplementary letter
EC	(numerals 1 to 4)	(numerals 1 to 3)	(letter S) **(1)**	(letter C) **(2)**

(1) The additional letter S indicates the resistance to salt mist (exposed decks, masts) of the electrical equipment.
(2) The supplementary letter C indicates the relative humidity up to 80% (air conditioned areas) in which the electrical equipment operates satisfactorily.

Table 3 : First characteristic numeral *(1/1/2025)*

First characteristic numeral	Brief description of location	Temperature range °C	
1	Air conditioned areas	+ 5	+ 40
2	Enclosed spaces	+ 5	+ 45
3a	Electronic equipment inside consoles, housing, etc..	+ 5	+ 55
3b	Close to combustion engines and similar	+ 5	+ 70
4	Exposed decks, masts	- 25	+ 45

Table 4 : Second characteristic numeral *(1/1/2025)*

Second characteristic numeral	Brief description of location	Frequency range Hz	Displacement amplitude mm	Acceleration amplitude g
1	Machinery spaces, command and control stations, accommodation spaces, exposed decks	from 2,0 to 13,2 from 13,2 to 100	1,0 -	- 0,7
2	Masts	from 2,0 to 13,2 from 13,2 to 50	3,0 -	- 2,1
3	On air compressors, on diesel engines and similar	from 2,0 to 25,0 from 25,0 to 100	1,6 -	- 4,0

SECTION 2 GENERAL DESIGN REQUIREMENTS

1 Environmental conditions

1.1 General

1.1.1 The electrical components of installations are to be designed and constructed to operate satisfactorily under the environmental conditions on board.

In particular, the conditions shown in the tables in this Article are to be taken into account.

Note 1: The environmental conditions are characterised by:

- one set of variables including climatic conditions (e.g. ambient air temperature and humidity), biological conditions, conditions dependent upon chemically active substances (e.g. salt mist) or mechanically active substances (e.g. dust or oil), mechanical conditions (e.g. vibrations or inclinations) and conditions dependent upon electromagnetic noise and interference, and
- another set of variables dependent mainly upon location on vessels, operational patterns and transient conditions.

1.2 Ambient air temperatures

1.2.1

For yachts classed for unrestricted navigation, the reference ambient air temperature ranges are shown in Tab 1 in relation to the various locations of installation.

1.2.2

Where electrical equipment is installed within environmentally controlled spaces, the ambient temperature for which the equipment is to be suitable may be reduced from 45° and maintained at a value not less than 35° provided:

- the equipment is not for use for emergency services.
- temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is (are) capable of satisfactorily maintaining the design temperature.
- the equipment is able to be initially set to work safely up to a 45° ambient temperature until such time as the lower ambient temperature is achieved; the cooling equipment is to be rated for a 45 ° ambient temperature.
- audible and visual alarms are fitted, at a continually manned control station, to indicate any malfunction of the cooling units.

1.2.3

In accepting an ambient temperature less than 45° it is to be ensured that electrical cables are adequately rated throughout their length for the maximum ambient temperature to which they are exposed.

1.2.4

The equipment used for cooling and maintaining the lower ambient temperature is to be classified for a secondary essential service.

1.2.5 For yachts classed to operate in specific zones, the Society may accept different ambient air temperature (e.g. for s operating outside the tropical belt, the maximum ambient air temperature may be assumed as equal to + 40 °C instead of + 45 °C).

Table 1 : Ambient air temperature *(1/1/2025)*

Location	Temperature range, in °C	
Enclosed spaces	+ 5	+ 45
Electronic equipment inside console, housing, etc.	+ 5	+ 55
Fitted on combustion engine and similar	+ 5	+ 70
Exposed decks	- 25	+ 45

1.3 Humidity

1.3.1 For yahtss classed for unrestricted service, the humidity ranges shown in Tab 2 are applicable in relation to the various locations of installation.

Table 2 : Humidity

Location	Humidity
General	95% at 55 °C
Air conditioned areas	Different values may be considered on a case by case basis

1.4 Cooling water temperatures

1.4.1 The temperatures shown in Tab 3 are applicable to yachts classed for unrestricted service.

1.4.2 For yachts classed to operate in specific zones, the Society may accept different values for the cooling water temperature (e.g. for s operating outside the tropical belt, the maximum cooling water temperature may be assumed as equal to + 25 °C instead of + 32 °C).

Table 3 : Water temperature

Coolant	Temperature range, in °C	
Sea water	0	+ 32

1.5 Salt mist

1.5.1 The applicable salt mist content in the air is to be 1 mg/m^3.

1.6 Inclinations

1.6.1 The inclinations applicable are those shown in Tab 4.

The Society may consider deviations from these angles of inclination taking into consideration the type, size and service conditions of the yachts.

1.7 Vibrations

1.7.1 In relation to the location of the electrical components, the vibration levels given in Tab 5 are to be assumed.

1.7.2 The natural frequencies of the equipment, their suspensions and their supports are to be outside the frequency ranges specified.

Where this is not possible using a suitable constructional technique, the equipment vibrations are to be dumped so as to avoid unacceptable amplifications.

2 Quality of power supply

2.1 Voltage and frequency variation

2.1.1

All electrical appliances supplied from the main or emergency systems are to be so designed and manufactured that they are capable of operating satisfactorily under the normally occurring variations in voltage and frequency.

2.1.2

Unless otherwise stated in national or international standards, all equipment is to operate satisfactorily with the variations from its rated value shown in Tab 6 to Tab 8 subject to the following conditions.

a) For alternating current components, the voltage and frequency variations shown in Tab 6 are to be assumed.

b) For direct current components supplied by d.c. generators or converted by rectifiers, the voltage variations shown in Tab 7 are to be assumed.

c) For direct current components supplied by electrical batteries, the voltage variations shown in Tab 8 are to be assumed.

2.1.3
Any special system, e.g. electronic circuits, whose function cannot operate satisfactorily within the limits shown in Tab 6, Tab 7 and Tab 8 is not to be supplied directly from the system but by alternative means, e.g. through stabilised supply.

2.2 Harmonic distortions

2.2.1 For components intended for systems without substantially static converter loads and supplied by synchronous generators, it is assumed that the total voltage harmonic distortion does not exceed 5%, and the single harmonic does not exceed 3% of the nominal voltage.

2.2.2 For components intended for systems fed by static converters, and/or systems in which the static converter load predominates, it is assumed that:

- the single harmonics do not exceed 5% of the nominal voltage up to the 15th harmonic of the nominal frequency, decreasing to 1% at the 100th harmonic (see Fig 1), and that
- the total harmonic distortion does not exceed 10%.

Table 4 : Inclination

Type of machinery, equipment or component	Angles of inclination, in degrees **(1)**			
	Athwart		Fore-and-aft	
	static	dynamic(3)	static	dynamic(4)
Machinery and equipment relative to main electrical power installation	15	22,5	5	7,5
Machinery and equipment relative to the emergency power installation and crew and passenger safety systems of the yacht (e.g. emergency source of power, emergency fire pumps, etc.)	22,5	22,5	10	10
Switchgear and associated electrical and electronic components and remote control systems (2)	22,5	22,5	10	10

(1) Athwart and fore-and-aft angles may occur simultaneously in their most unfavourable combination.
(2) No undesired switching operations or functional changes are to occur.
(3) The period of dynamic inclination may be assumed equal to 10 s.
(4) The period of dynamic inclination may be assumed equal to 5 s.

Table 5 : Vibration levels *(1/1/2025)*

Location	Frequency range Hz	Displacement amplitude mm	Acceleration amplitude g
Machinery spaces, command and control stations, accommodation spaces, exposed decks	from 2,0 to 13,2 from 13,2 to 100	1,0 -	- 0,7
On air compressors, on diesel engines and similar	from 2,0 to 25,0 from 25,0 to 100	1,6 -	- 4,0
Masts	from 2,0 to 13,2 from 13,2 to 50	3,0 -	- 2,1

Figure 1

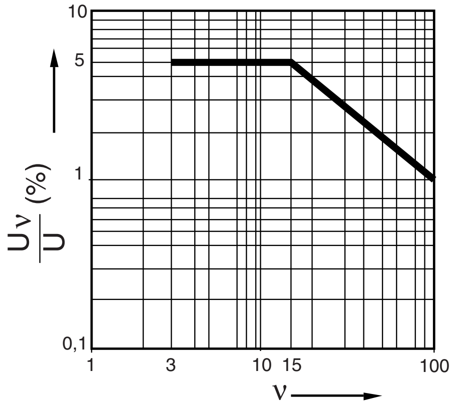


Table 6 : Voltage and frequency variations for a.c. distribution systems

Quantity in operation	Variations	
	Continuous	Transient
Voltage	+ 6% - 10%	± 20% (recovery time: 1,5 s)
Frequency	± 5%	± 10% (recovery time: 5 s)

Table 7 : Voltage variations for d.c. distribution systems

Parameters	Variations
Voltage tolerance (continuous)	± 10%
Voltage cyclic variation deviation	5%
Voltage ripple (a.c. r.m.s. over steady d.c. voltage)	10%

2.2.3 Where harmonic filters are fitted onboard, e.g. in electric propulsion plant systems, the total harmonic distortion (THD) of electrical distribution systems is not to exceed 8%. This limit may be exceeded where all installed equipment and systems have been designed for a higher specified limit and this relaxation on limits is to be documented (harmonic distortion calculation report) and made available onboard as a reference for the surveyor in charge for survey.

Note 1: installation where harmonic filters are installed for single application frequency drives such as pump motors, are exclude from the application of this requirement.

Table 8 : Voltage variations for battery systems

Systems	Variations
Components connected to the battery during charging **(1)**	+30%, -25%
Components not connected to the battery during charging	+20%, -25%
(1) Different voltage variations as determined by the charging/discharging characteristics, including ripple voltage from the charging device, may be considered.	

3 Electromagnetic susceptibility

3.1

3.1.1 For electronic type components such as sensors, alarm panels, automatic and remote control equipment, protective devices and speed regulators, the conducted and radiated disturbance levels to be assumed are those given in Chapter 3.

Note 1: See also IEC Publication 60533 - “Electromagnetic Compatibility of Electrical and Electronic Installations in s and of Mobile and Fixed Offshore Units”.

4 Materials

4.1 General

4.1.1 In general, and unless it is adequately protected, all electrical equipment is to be constructed of durable, flame-retardant, moisture-resistant materials which are not subject to deterioration in the atmosphere and at the temperatures to which they are likely to be exposed. Particular consideration is to be given to sea air and oil vapour contamination.

Note 1: The flame-retardant and moisture-resistant characteristics may be verified by means of the tests cited in IEC Publication 60092-101 or in other recognised standards.

4.1.2 Where the use of incombustible materials or lining with such materials is required, the incombustibility characteristics may be verified by means of the test cited in IEC Publication 60092-101 or in other recognised standards.

4.2 Insulating materials for windings

4.2.1 Insulated windings are to be resistant to moisture, sea air and oil vapour unless special precautions are taken to protect insulants against such agents.

4.2.2

The insulation classes given in Tab 9 may be used.

Table 9 : Insulation Classes

Class	Maximum continuous operating temperature °C
A	105
E	120
B	130
F	155
H	180

4.3 Insulating materials for cables

4.3.1 See Sec 9, [1.3].

5 Construction

5.1 General

5.1.1 All electrical apparatus is to be so constructed as not to cause injury when handled or touched in the normal manner.

5.1.2 The design of electrical equipment is to allow accessibility to each part that needs inspection or adjustment, also taking into account its arrangement on board.

5.1.3 Enclosures are to be of adequate mechanical strength and rigidity.

5.1.4 Enclosures for electrical equipment are generally to be of metal; other materials may be accepted for accessories such as connection boxes, socket-outlets, switches and luminaires. Other exemptions for enclosures or parts of enclosures not made of metal will be specially considered by the Society.

5.1.5 Cable entrance are not to impair the degree of protection of the relevant enclosure (see Sec 3, Tab 2).

5.1.6 All nuts and screws used in connection with current-carrying parts and working parts are to be effectively locked.

5.1.7 All equipment is generally to be provided with suitable, fixed terminal connectors in an accessible position for convenient connection of the external cables.

5.2 Degree of protection of enclosures

5.2.1 Electrical equipment is to be protected against the ingress of foreign bodies and water.

The minimum required degree of protection, in relation to the place of installation, is generally that specified in Sec 3, Tab 2.

5.2.2 The degrees of protection are to be in accordance with:

- IEC Publication No. 60529 for equipment in general
- IEC Publication No. 60034-5 for rotating machines.

5.2.3 For cable entries see [4.3.1].

6 Protection against explosion hazard and dust hazard

6.1 Protection against explosive gas or vapour atmosphere hazard

6.1.1 Electrical equipment intended for use in areas where explosive gas or vapour atmospheres may occur is to be of a "safe type" suitable for the relevant flammable atmosphere and for board use.

6.2 Protection against combustible dust hazard

6.2.1 Electrical appliances intended for use in areas where a combustible dust hazard may be present are to be arranged with enclosures having a degree of protection and maximum surface temperature suitable for the dust to which they may be exposed.

Note 1: Where the characteristics of the dust are unknown, the appliances are to have a degree of protection IP6X. For most dusts a maximum surface temperature of 200°C is considered adequate.

SECTION 3 SYSTEM DESIGN

1 Supply systems and characteristics of the supply

1.1 Supply systems

1.1.1 The following distribution systems may be used:

a) on d.c. installations:
- two-wire insulated
- two-wire with one pole earthed

b) on a.c. installations:
- three-phase three-wire with neutral insulated
- three-phase three-wire with neutral directly earthed or earthed through an impedance
- three-phase four-wire with neutral directly earthed or earthed through an impedance
- single-phase two-wire insulated
- single-phase two-wire with one phase earthed.

1.1.2 Distribution systems other than those listed in [1.1.1] (e.g. with hull return, three-phase four-wire insulated) will be considered by the Society on a case by case basis.

1.1.3 The hull return system of distribution is not to be used for power, heating or lighting.

1.1.4 The requirement of [1.1.3] does not preclude under conditions approved by the Society the use of:

a) impressed current cathodic protective systems,

b) limited and locally earthed systems, or

c) insulation level monitoring devices provided the circulation current does not exceed 30 mA under the most unfavourable conditions.

Note 1: Limited and locally earthed systems such as starting and ignition systems of internal combustion engines are accepted provided that any possible resulting current does not flow directly through any dangerous spaces.

1.1.5 For the supply systems in HV Installations, see Sec 13.

1.2 Maximum voltages

1.2.1 The maximum voltages for both alternating current and direct current low-voltage systems of supply for the yacht’s services are given in Tab 1.

Table 1 : Maximum voltages for various services

Use		Maximum voltage, in V
For permanently installed and connected to fixed wiring	Power equipment	1000
	Heating equipment (except in accommodation spaces)	500
	Cooking equipment	500
	Lighting	250
	Space heaters in accommodation spaces	250
	Control **(1)**, communication (including signal lamps) and instrumentation equipment	250
For permanently installed and connected by flexible cable	Power and heating equipment, where such connection is necessary because of the application (e.g. for moveable cranes or other hoisting gear)	1000
For socket-outlets supplying	Portable appliances which are not hand-held during operation (e.g. refrigerated containers) by flexible cables	1000
	Portable appliances and other consumers by flexible cables	250
	Equipment requiring extra precaution against electric shock where an isolating transformer is used to supply one appliance **(2)**	250
	Equipment requiring extra precaution against electric shock with or without a safety transformer **(2)**.	50

(1) For control equipment which is part of a power and heating installation (e.g. pressure or temperature switches for starting/stopping motors), the same maximum voltage as allowed for the power and heating equipment may be used provided that all components are constructed for such voltage. However, the control voltage to external equipment is not to exceed 500 V.

(2) Both conductors in such systems are to be insulated from earth.

1.2.2 Voltages exceeding those shown will be specially considered in the case of specific systems.

1.2.3 For high voltage systems see Sec 13.

2 Sources of electrical power

2.1 General

2.1.1 Electrical installations are to be such that:

a) All electrical auxiliary services necessary for maintaining the yacht in normal operational and habitable conditions will be assured without recourse to the emergency source of electrical power.

b) Electrical services essential for safety will be assured under various emergency conditions.

c) When a.c. generators are involved, attention is to be given to the starting of squirrel-cage motors connected to the system, particularly with regard to the effect of the magnitude and duration of the transient voltage change produced due to the maximum starting current and the power factor. The voltage drop due to such starting current is not to cause any motor already operating to stall or have any adverse effect on other equipment in use.

2.2 Main source of electrical power

2.2.1 A main source of electrical power is to be provided, of sufficient capability to supply all electrical auxiliary services necessary for maintaining the yacht in normal operational and habitable conditions without recourse to the emergency source of electrical power.

2.2.2 For yachts propelled by electrical power and having two or more constant voltage propulsion generating sets which constitute the source of electrical energy for the yacht's auxiliary services, see Sec 14.

2.2.3

The main source of electrical power is to consist of at least two generating sets.

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:

a) minimum operational conditions of propulsion so to ensure yacht manoeuvrability and normal conditions of safety (see [2.2.4])

b) minimum comfortable conditions of habitability (see Sec 1, [3.4.2])

Such capacity is, in addition, to be sufficient to start the largest motor without causing any other motor to stop or having any adverse effect on other equipment in operation.

2.2.4 Those services necessary to provide minimum operational conditions of propulsion and normal condition of safety include primary and secondary essential services.

For the purpose of calculating the capacity necessary for such services, it is essential to consider which of them can be expected to be in use simultaneously.

For a duplicated service, one being supplied electrically and the other non-electrically (e.g. driven by the main engine), the electrical capacity is not included in the above calculation.

2.2.5 The services in [2.2.4] do not include:

- thrusters not forming part of the main propulsion
- refrigerators for air conditioning.

2.2.6 Further to the provisions above, the generating sets shall be such as to ensure that with any one generator or its primary source of power out of operation, the remaining generating sets shall be capable of providing the electrical services necessary to start the main propulsion plant from a "dead " condition.

2.2.7 The emergency source of electrical power may be used for the purpose of starting from a "dead ship" condition if its capability either alone or combined with that of any other source of electrical power is sufficient to provide at the same time those services required to be supplied in accordance with the provisions of [3.7.3] (items a, b, c, d).

2.2.8 The arrangement of the yacht’s main source of electrical power shall be such that essential services can be maintained regardless of the speed and direction of rotation of the main propulsion machinery or shafting.

2.2.9 Generators driven by the propulsion plant (shaft generators) which are intended to operate at constant speed (e.g. a system where vessel speed and direction are controlled by varying propeller pitch) may be accepted as forming part of the main source of electrical power if, in all sailing and manoeuvring conditions including the propeller being stopped, the capacity of these generators is sufficient to provide the electrical power to comply with [2.2.3] and all further requirements, especially those of [2.2.6]. They are to be not less effective and reliable than the independent generating sets.

2.2.10

Generators and generator systems, having the yacht's propulsion machinery as their prime mover but not forming part of the yacht's main source of electrical power (see Note 1) may be used whilst the yacht is at sea to supply electrical services required for normal operational and habitable conditions, provided that:

a) there are sufficient and adequately rated additional generators fitted, which constitute the main source of electrical power required by [2.2.1], meeting the provisions of [2.2.8]

b) arrangements are fitted to automatically start one or more of the generators constituting the main source of electrical power required by [2.2.1], in compliance with [3.4.5] and also in the event of frequency variations exceeding ± 10% of the limits specified below

c) within the declared operating range of the generators and/or generator systems, the specified limits for the voltage variations in IEC 60092-301/AMD2 and the frequency variations in Sec 2, Tab 6 can be met

d) the short-circuit current of the generator and/or generator system is sufficient to trip the generator/generator system circuit-breaker taking into account the selectivity of the protective devices for the distribution system

e) where considered appropriate, load shedding arrangements are fitted to meet the requirements of [3.4.6], [3.4.7] and [3.4.8]

f) on yachts having remote control of the propulsion machinery from the navigating bridge, means are provided or procedures are in place so as to ensure that supplies to essential services are maintained during manoeuvring conditions in order to avoid a blackout situation (see Note 2).

Note 1: Such generator systems are those whose operation does not meet the requirements of IEC 60092-201, paragraph 8.1.1.

Note 2: A ‘blackout situation’ means that the main and auxiliary machinery installations, including the main power supply, are out of operation but the services for bringing them into operation (e.g. compressed air, starting current from batteries etc.) are available.

2.2.11

Where transformers, converters or similar appliances constitute an essential part of the electrical supply system, the system is to be so arranged as to ensure the same continuity of supply as stated in this sub-article [2.2].

This may be achieved by arranging at least two three-phase or three single-phase transformers supplied, protected and installed as indicated in Fig 1, so that with any one transformer not in operation, the remaining transformer(s) is (are) sufficient to ensure the supply to the services stated in [2.2.3].

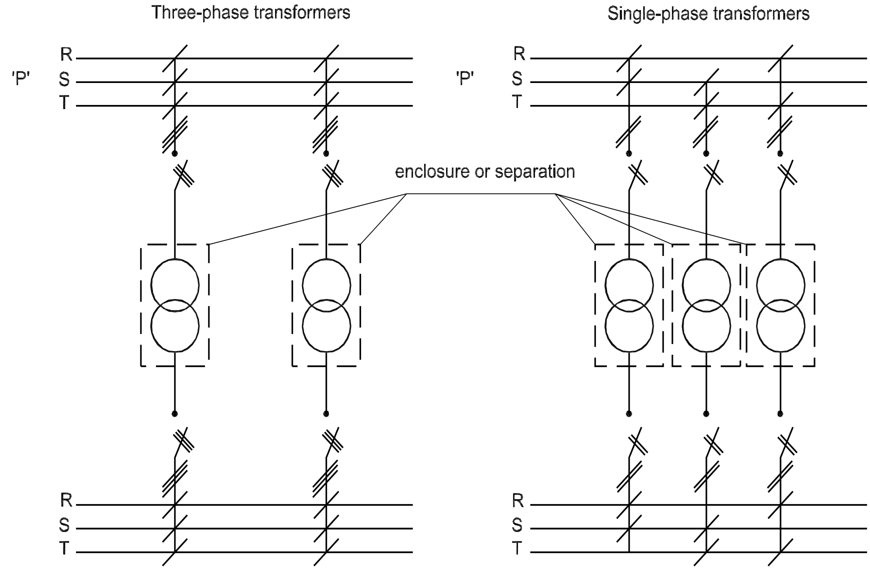
Each transformer required is to be located as a separate unit with separate enclosure or equivalent, and is to be served by separate circuits on the primary and secondary sides. Each of the primary circuits is to be provided with switchgears and protection devices in each phase. Each of the secondary circuits is to be provided with a multiple isolating switch.

Suitable interlocks or a warning label are to be provided in order to prevent maintenance or repair of one single-phase transformer unless both switchgears are opened on their primary and secondary sides.

2.2.12 For yachts intended for operation with periodically unattended machinery spaces, see Part F, Chapter 2.

2.2.13 For starting arrangements for main generating sets, see Ch 1, Sec 2, [5.1].

Figure 1



2.3 Emergency source of electrical power

2.3.1 A self-contained emergency source of electrical power shall be provided.

2.3.2 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.

Exceptionally is understood to mean conditions, while the vessel is at sea, such as:

a) blackout situation

b) dead ship situation (when applicable)

c) routine use for testing

d) short-term parallel operation with the main source of electrical power for the purpose of load transfer.

Unless otherwise instructed by the Society, the emergency generator may be used during lay time in port for the supply of the yacht mains, provided the requirements of [2.4] are complied with.

2.3.3 The electrical power available shall 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.

2.3.4 The emergency source of electrical power shall be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the services stated in [3.7.3] for the period specified, if they depend upon an electrical source for their operation.

2.3.5 The transitional source of emergency electrical power, where required, is to be of sufficient capacity to supply at least the services stated in [3.7.7] for half an hour, if they depend upon an electrical source for their operation.

2.3.6 An indicator shall be mounted in a suitable place on the main switchboard or in the machinery control room and at the navigating bridge to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power referred to in [2.3.13] and [2.3.14] are being discharged.

2.3.7 If the services which are to be supplied by the transitional source receive power from an accumulator battery by means of semiconductor convertors, means are to be provided for supplying such services also in the event of failure of the convertor (e.g. providing a bypass feeder or a duplication of convertor).

2.3.8 (1/1/2025)

Where electrical power is necessary to restore propulsion, the capacity of the emergency source shall be sufficient to restore propulsion to the yacht in conjunction to other machinery as appropriate, from a dead ship condition.

For the purpose of this requirement only, the dead condition and blackout are both understood to mean a condition under which the main propulsion plant and auxiliaries are not in operation and in restoring the propulsion, no stored energy for starting the propulsion plant, the main source of electrical power and other essential auxiliaries is to be assumed available. It is assumed that means are available to start the emergency generator at all times.

Emergency generator stored starting energy is not to be directly used for starting the propulsion plant, the main source of electrical power and/or other essential auxiliaries (emergency generator excluded).

2.3.9 Provision shall be made for the periodic testing of the complete emergency system and shall include the testing of automatic starting arrangements, where provided.

2.3.10 For starting arrangements for emergency generating sets, see Ch 1, Sec 2, [5.1].

2.3.11 The emergency source of electrical power may be either a generator or an accumulator battery which shall comply with the requirements of [2.3.12] or [2.3.13], respectively.

2.3.12 Where the emergency source of electrical power is a generator, it shall be:

a) driven by a suitable prime mover with an independent supply of fuel, having a flashpoint (closed cup test) of not less than 43°C;
b) started automatically upon failure of the main source of electrical power supply to the emergency switchboard unless a transitional source of emergency electrical power in accordance with (c) below is provided; where the emergency generator is automatically started, it shall be automatically connected to the emergency switchboard; those services referred to in [3.7.7] shall then be connected automatically to the emergency generator; and
c) provided with a transitional source of emergency electrical power as specified in [2.3.14] unless an emergency generator is provided capable both of supplying the services mentioned in that paragraph and of being automatically started and supplying the required load as quickly as is safe and practicable subject to a maximum of 45 s.

2.3.13 Where the emergency source of electrical power is an accumulator battery it shall be capable of:

a) 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;
b) automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and
c) immediately supplying at least those services specified in [3.7.7].

2.3.14 The transitional source of emergency electrical power where required by [2.3.12] (item c) shall consist of an accumulator battery which shall operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and 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 services in [3.7.7] if they depend upon an electrical source for their operation.

2.3.15

When the emergency generator room ventilation system is fitted with closable ventilation louvers and ventilator closing appliances, the following requirements apply:

a) ventilation louvers and closing appliances may either be hand-operated or power-operated (hydraulic / pneumatic / electric) and are to be operable under a fire condition;
b) hand-operated ventilation louvers and closing appliances are to be kept open during normal operation of the vessel. Corresponding instruction plates are to be provided at the location where hand-operation is provided;
c) power-operated ventilation louvers and closing appliances are to be of a fail-to-open type. Closed power-operated ventilation louvers and closing appliances are acceptable during normal operation of the vessel;

d) power-operated ventilation louvers and closing appliances are to open automatically whenever the emergency generator is starting / in operation;

e) it is to be possible to close ventilation openings by a manual operation from a clearly marked safe position outside the space, where the closing operation can be easily confirmed. The louver status (open / closed) shall be indicated at this position. Such closing shall not be possible from any other remote position.

2.4 Use of emergency generator in port

2.4.1 To prevent the 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 operation.

2.4.2 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.

2.4.3 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 [3.7].

2.4.4 The prime mover is to be designed and built for continuous operation and should 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.

2.4.5 Fire detectors are to be installed in the location where the emergency generator set and emergency switchboard are installed.

2.4.6 Means are to be provided to readily change over to emergency operation.

2.4.7 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.

2.4.8 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.

2.5 Measuring Instruments

2.5.1 Measuring instruments shall comply with IEC 60092-507, [4.5.6]. Multifunctional digital equipment, where practicable, can be installed, one for each power source..

3 Distribution

3.1 Earthed distribution systems

3.1.1 System earthing is to be effected by means independent of any earthing arrangements of the non-current-carrying parts.

3.1.2 Means of disconnection are to be fitted in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance or insulation resistance measurements.

3.1.3 Generator neutrals may be connected in common, provided that the third harmonic content of the voltage wave form of each generator does not exceed 5%.

3.1.4 Where a switchboard is split into sections operated independently or where there are separate switchboards, neutral earthing is to be provided for each section or for each switchboard. Means are to be provided to ensure that the earth connection is not removed when generators are isolated.

3.1.5 Where for final sub-circuits it is necessary to locally connect a pole (or phase) of the sub-circuits to earth after the protective devices (e.g. in automation systems or to avoid electromagnetic disturbances), provision (e.g. d.c./d.c. convertors or transformers) is to be made such that current unbalances do not occur in the individual poles or phases.

3.1.6 For high voltage systems see Sec 13.

3.2 Insulated distribution systems

3.2.1 Every insulated distribution system, whether primary or secondary (see Note 1), for power, heating or lighting, shall be provided with a device capable of continuously monitoring the insulation level to earth (i.e. the values of electrical insulation to earth) and of giving an audible and visual indication of abnormally low insulation values.

Note 1: A primary system is one supplied directly by generators. Secondary systems are those supplied by transformers or convertors.

3.2.2 For high voltage systems see Sec 13.

3.3 Distribution systems with hull return

3.3.1 Where the hull return system is used, if permitted, all final sub-circuits, i.e. all circuits fitted after the last protective device, shall be two-wire.

The hull return is to be achieved by connecting to the hull one of the busbars of the distribution board from which the final sub-circuits originate.

3.4 General requirements for distribution systems

3.4.1 The distribution system is to be such that the failure of any single circuit will not endanger or impair primary essential services and will not render secondary essential services inoperative for longer periods.

3.4.2 No common switchgear (e.g. contactors for emergency stop) is to be used between the switchboard’s busbars and two primary non duplicated essential services.

3.4.3 Where the main source of electrical power is necessary for propulsion and steering of the yacht, the system shall be so arranged that the electrical supply to equipment necessary for propulsion and steering and to ensure safety of the yacht will be maintained or immediately restored in the case of loss of any one of the generators in service.

3.4.4

Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, provision of protection, including automatic disconnection of sufficient non-essential services and if necessary secondary essential services and those provided for habitability, are to be made to ensure that, in case of loss of any of these generating sets, the remaining ones are kept in operation to permit propulsion and steering and to ensure safety.

3.4.5

Where the electrical power is normally supplied by one generator, provision are to be made, upon loss of power, for automatic starting and connecting to the main switchboard of stand-by generator(s)of sufficient capacity with automatic restarting of the essential auxiliaries, in sequential operation if required. Starting and connection to the main switchboard of one generator is to be as rapid as possible, preferably within 30 seconds after loss of power.

Where prime movers with longer starting time are used, this starting and connection time may be exceeded upon approval from the Society.

3.4.6

Load shedding or other equivalent arrangements are to be provided to protect the generators against sustained overload.

3.4.7

The load shedding is to be automatic.

3.4.8

The non-essential services, service for habitable conditions may be shed and, where necessary, additionally, the secondary essential services, sufficient to ensure the connected generator set or generator sets are not overloaded.

3.5 Harmonic distortion for electrical distribution system including harmonic filters

3.5.1 Monitoring of harmonic distortion levels for s including harmonic filters

For s where harmonic filters are installed on main busbars of electrical distribution system facilities to continuously monitor the levels of harmonic distortion experienced on the main busbar, as well as alerting the crew should the level of harmonic distortion exceed the acceptable limits, are to be fitted.

Where the engine room is provided with automation systems, the reading should be logged electronically, otherwise the reading is to be recorded in the engine log book for inspection by the surveyor.

3.5.2 Protection arrangements for harmonic filters

The harmonic filters should be arranged as three phase units with individual protection of each phase.

The activation of the protection arrangement in a single phase is to result in automatic disconnection of the complete filter.

Additionally, a current unbalance detection system, independent of the overcurrent protection, alerting the crew in case of current unbalance, is to be provided.

Arrangements are to be provided to alert the crew in the event of activation of the protection of a harmonic filter circuit.

Consideration is to be given to additional protection for the individual capacitor element as e.g. relief valve or overpressure disconnector in order to protect against damage from rupturing; this consideration should take into account the type of capacitors used.

3.5.3 Mitigation of the effects of harmonic filter failure on a yacht's operation

The system integrator of the distribution system is to show, by calculation, the effect of a failure of a harmonic filter on the level of harmonic distortion experienced.

The system integrator of the distribution system is to provide the yacht Owner with guidance documenting permitted modes of operation of the electrical distribution system while maintaining harmonic distortion levels within acceptable limits during normal operation as well as following the failure of any combination of harmonic filters.

The calculation results and validity of the guidance provided are to be verified by the surveyor during sea trials.

Note 1: harmonic filters installed for single application frequency drives, such as pump motors, may be excluded from requirements of [3.5].

3.6 Main distribution of electrical power

3.6.1 Where the main source of electrical power is necessary for propulsion and steering of the yacht, the main busbar is to be divided into at least two parts which are normally to be connected by circuit breakers or other approved means such as circuit breakers without tripping mechanisms or disconnecting links or switches by means of which busbars can be split safely and easily.

The connection of generating sets and associated auxiliaries and other duplicated equipment is to be equally divided between the parts as far as practicable, so that in the event of damage to one section of the switchboard the remaining parts are still supplied.

3.6.2

Two or more units serving the same consumer (e.g. main and standby lubricating oil pumps) are to be supplied by individual separate circuits without the use of common feeders, protective devices or control circuits.

This requirement is satisfied when such units are supplied by separate cables from the main switchboard or from two independent distribution boards.

3.6.3 A main electric lighting system which shall provide illumination throughout those parts of the yacht normally accessible to and used by people on board shall be supplied from the main source of electrical power.

3.7 Emergency distribution of electrical power

3.7.1 The emergency switchboard shall be supplied during normal operation from the main switchboard by an interconnector feeder which shall 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.

3.7.2 In order to ensure ready availability of the emergency source of electrical power, arrangements shall be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that power shall be available to the emergency circuits.

3.7.3

The emergency source of electrical power shall be capable of supplying simultaneously at least the following services for the periods specified hereafter, if they depend upon an electrical source for their operation:

a) for a period of 3 hours, emergency lighting at every muster and embarkation station and over the sides;

b) for a period of 18 hours, emergency lighting:

   1) in all service and accommodation alleyways, stairways and exits;

   2) in the machinery spaces and main generating stations including their control positions;

   3) in all control stations, machinery control rooms, and at each main and emergency switchboard;

   4) at all stowage positions for firemen's outfits;

   5) at the steering gear;

   6) at the fire pump referred to in (e) below, at the sprinkler pump, if any, at the emergency bilge pump, if any, and at the starting positions of their motors; and

c) for a period of 18 hours:

   1) the navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force;

   2) radio as per Flag Administration requirements;

d) for a period of 18 hours:

   1) all internal communication equipment as required in an emergency [3.7.4];

   2) the borne navigational equipment as required by Flag Administration;

   3) the fire detection and fire alarm systems ; and

   4) intermittent operation of the daylight signalling lamp, the whistle, the manually operated call points and all internal signals (see [3.7.5]) that are required in an emergency;

   unless such services have an independent supply for the period of 18 hours from an accumulator battery suitably located for use in an emergency;

e) for a period of 18 hours: one of the fire pumps, when required, if dependent upon the emergency generator for its source of power ;

f) for the period of time required in Ch 1, Sec 11, [2], the steering gear where it is required to be so supplied.

g) f) g)For a period of 18 hours any other system or electrical equipment required by the Rule (e.g. bilge and fire systems, rudders indicators, gas detection system…) .

3.7.4

Internal communication equipment required in an emergency generally includes:

a) the means of communication between the navigating bridge and the steering gear compartment

b) the means of communication between the navigating bridge and the position in the machinery space or control room from which the engines are normally controlled

c) the public address system when required by Flag Administration.

3.7.5

Internal signals required in an emergency generally include:

a) general alarm (see Sec 1, [1.1.2]) where required by Flag Administration

b) watertight door indication.

3.7.6 The transitional source of emergency electrical power, where required, shall supply for half an hour at least the following services if they depend upon an electrical source for their operation:

a) the lighting required by [3.7.3](item a, b, c1); for this transitional phase, the required emergency electric lighting, in respect of the machinery space and the accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps; and

b) all services required by [3.7.3] (item d1, d3, d4) unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

3.8 Shore supply

3.8.1 Where arrangements are made for supplying the electrical installation from a source on shore or elsewhere, a suitable connection box is to be installed on the yacht in a convenient location to receive the flexible cable from the external source.

3.8.2
Permanently fixed cables of adequate rating are to be provided for connecting the box to the main switchboard or emergency switchboard.

3.8.3 Where necessary for systems with earthed neutrals, the box is to be provided with an earthed terminal for connection between the shore's and yacht's neutrals or for connection of a protective conductor.

3.8.4
The connection box is to contain a circuit-breaker or a switch-disconnector and fuses.

The shore connection is to be protected against short-circuit and overload; however, the overload protection may be omitted in the connection box if provided on the main or emergency switchboard.

3.8.5 Means are to be provided for checking the phase sequence of the incoming supply in relation to the yacht's system.

3.8.6
The cable connection to the box is to be provided with at least one switch-disconnector on the main or emergency switchboard.

3.8.7
The shore connection is to be provided with an indicator at the main or emergency switchboard in order to show when the cable is energised.

3.8.8 At the connection box a notice is to be provided giving full information on the nominal voltage and frequency of the installation.

3.8.9
The switch-disconnector on the main or emergency switchboard is to be interlocked with the generator circuit-breakers in order to prevent its closure when any generator is supplying the main or emergency switchboard unless special provisions to the satisfaction of the Society are taken to permit safe transfer of electrical load.

3.8.10 Adequate means are to be provided to equalise the potential between the hull and the shore when the electrical installation of the is supplied from shore.

3.9 Supply of motors

3.9.1 A separate final sub-circuit is to be provided for every motor required for an essential service (and for every motor rated at 1 kW or more).

3.9.2 Each motor is to be provided with controlgear ensuring its satisfactory starting.

Depending on the capacity of the generating plant or the cable network, it may be necessary to limit the starting current to an acceptable value.

Direct on line starters are accepted if the voltage drop does not exceed 15% of the network voltage.

3.9.3 Efficient means are to be provided for the isolation of the motor and its associated control gear from all live poles of the supply.

Where the control gear is mounted on or adjacent to a switchboard, a disconnecting switch in the switchboard may be used for this purpose.

Otherwise, a disconnecting switch within the control gear enclosure or a separate enclosed disconnecting switch is to be provided.

3.9.4 Where the starter or any other apparatus for disconnecting the motor is remote from the motor itself, one of the following is to be arranged:

a) provision for locking the circuit disconnecting switch in the OFF position

b) an additional disconnecting switch fitted near the motor

c) provision such that the fuses in each live pole or phase can be readily removed and retained by persons authorised to have access to the motor.

3.10 Specific requirements for special power services

3.10.1 For the supply and characteristics of the distribution of the following services see the requirements listed:

- Steering gear: Ch 1, Sec 11,
- Fire-extinguishing and detecting systems: Ch 4, Sec 4 and Sec 8
- Ventilation fans: Chapter 4
- Fuel pumps: Ch 1, Sec 10

3.11 Power supply to heaters

3.11.1 Each heater rated more than 16A is to be connected to a separate final circuit.

3.12 Power supply to lighting installations

3.12.1 Final sub-circuits for lighting supplying more than one lighting point and for socket-outlets are to be fitted with protective devices having a current rating not exceeding 16 A.

3.13 Navigation lights

3.13.1

Navigation lights are to be connected separately to a distribution board specially reserved for this purpose.

Signalling lights may be connected to the navigation light distribution board, or to a separate distribution board.

3.13.2

The navigation light distribution board is to be supplied from two alternative circuits, one from the main source of power and one from the emergency source of power; see also [3.7].

The transfer of supply is to be practicable from the bridge, for example by means of a switch.

3.13.3 Each navigation light is to be controlled and protected in each insulated pole by a double-pole switch and a fuse or, alternatively, by a double-pole circuit-breaker, fitted on the distribution board referred to in [3.13.1].

3.13.4 Where there are double navigation lights, i.e. lights with two lamps or where for every navigation light a spare is also fitted, the connections to such lights may run in a single cable provided that means are foreseen in the distribution board to ensure that only one lamp or light may be supplied at any one time.

3.13.5 Each navigation light is to be provided with an automatic indicator giving audible and/or visual warning in the event of failure of the light. If an audible device alone is fitted, it is to be connected to a separate source of supply from that of the navigation lights, for example an accumulator (storage) battery.

If a visual signal is used connected in series with the navigation light, means are to be provided to prevent the extinction of the navigation light due to the failure of the visual signal.

A minimum level of visibility is to be assured in the case of use of dimmer devices.

3.14 General emergency alarm system

3.14.1

For the application of this [3.14] see relevant requirements of the Flag Administration.

3.14.2

An electrically operated bell or klaxon or other equivalent warning system installed in addition to the 's whistle or siren, for sounding the general emergency alarm signal, is to comply with the requirements of this sub-article.

The system is to be capable of operation from the navigating bridge, it is to be continuously supplied from an emergency source of electrical power.

3.14.3 The general emergency alarm system is to be supplemented by either a public address system complying with the requirements in [3.16] or other suitable means of communication.

3.14.4 Entertainment sound system is to be automatically turned off when the general alarm system is activated.

3.14.5 An alarm is to be given in the event of power failure to the system.

3.14.6 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 (where applicable).

3.14.7 The alarm system is to be audible throughout all the accommodation and normal crew working spaces.

3.14.8 The minimum sound pressure level for the emergency alarm tone in interior and exterior spaces is to be 80 dB (A) and at least 10 dB (A) above ambient noise levels occurring during normal equipment operation with the yacht underway in moderate weather.

3.14.9 In cabins without a loudspeaker installation, an electronic alarm transducer, e.g. a buzzer or similar, is to be installed.

3.14.10 The sound pressure level at the sleeping position in cabins and in cabin bathrooms is to be at least 75 dB (A) and at least 10 dB (A) above ambient noise levels.

3.14.11 For cables used for the general emergency alarm system, see [9.6].

3.15 Public address system

3.15.1

Where required by Flag Administration a public address system shall be installed and the following paragraphs apply..

3.15.2

The public address system is to be a loudspeaker installation enabling the broadcast of messages into all spaces where people on board are normally present.

3.15.3

In spaces such as under deck passageways, bosun’s locker, hospital and pump rooms, the public address system is/may not be required.

3.15.4 Where the public address system is used to supplement the general emergency alarm system as per [3.15.3], it is to be continuously powered from the emergency source of electrical power required by [3.7].

3.15.5 The system is to allow for the broadcast of messages from the navigation bridge and from other places on board the as deemed necessary.

3.15.6 The system is to be protected against unauthorised use.

3.15.7 The system is to be installed with regard to acoustically marginal conditions and not require any action from the addressee.

3.15.8 Where an individual loudspeaker has a device for local silencing, an override arrangement from the control station(s), including the navigating bridge, is to be in place.

3.15.9 With the underway in normal conditions, the minimum sound pressure level for broadcasting emergency announcements is to be:

a) in interior spaces, 75 dB (A) and at least 20 dB (A) above the speech interference level

b) in exterior spaces, 80 dB (A) and at least 15 dB (A) above the speech interference level.

With respect to cabin/state rooms, the sound pressure level is to be attained as required inside such spaces during sea trials.

3.15.10

For cables used for the public address system, see [9.6].

3.16 Combined general emergency alarm - public address system

3.16.1

When both generally emergency alarm and public address system are required by the Flag Administration, the following apply.

3.16.2 Where the public address system is the only means for sounding the general emergency alarm signal and the fire alarm, in addition to the requirements of [3.15] and [3.16], the following are to be satisfied:

- the system automatically overrides any other input system when an emergency alarm is required
- the system automatically overrides any volume control provided to give the required output for the emergency mode when an emergency alarm is required
- the system is arranged to prevent feedback or other interference
- the system is arranged to minimise the effect of a single failure so that the alarm signal is still audible (above ambient noise levels) also in the case of failure of any one circuit or component, by means of the use of:
  - multiple amplifiers
  - segregated cable routes to public rooms, alleyways, stairways and control stations
  - more than one device for generating electronic sound signal
  - electrical protection for individual loudspeakers against short-circuits.

3.17 Control and indication circuits

3.17.1 For the supply of automation systems, comprising control, alarm and safety system, see the requirements of Chapter 3.

3.17.2 Control and indicating circuits relative to primary essential services are to be branched off from the main circuit in which the relevant equipment is installed. Equivalent arrangements may be accepted by the Society.

3.17.3 Control and indicating circuits relative to secondary essential services and to non-essential services may be supplied by distribution systems reserved for the purpose to the satisfaction of the Society.

3.18 Power supply to the speed control systems of main propulsion engines

3.18.1 Electrically operated speed control systems of main engines are to be fed from the main source of electrical power.

3.18.2

Where more than one main propulsion engine is foreseen, each speed control system is to be provided with an individual supply by means of separate wiring from the main switchboard or from two independent distribution boards.

Where the main busbars are divided into two sections, the governors are, as far as practicable, to be supplied equally from the two sections.

3.18.3 In the case of propulsion engines which do not depend for their operation on electrical power, i.e. pumps driven from the main engine, the speed control systems are to be fed both from the main source of electrical power and from an accumulator battery for at least 15 minutes or from a similar supply source.

Such battery may also be used for other services such as automation systems, where foreseen.

3.19 Power supply to the speed control systems of generator sets

3.19.1 Each electrically operated control and/or speed control system of generator sets is to be provided with a separate supply from the main source of electric power and from an accumulator battery for at least 15 minutes or from a similar supply source.

3.19.2 The wiring supplying the main source of electrical power is to be from the main switchboard or from independent section boards.

Where the main busbars are divided into two sections, the governors are, as far as practicable, to be supplied from the sections to which the relevant generators are connected.

4 Degrees of protection of the enclosures

4.1 General

4.1.1 The minimum required degree of protection for electrical equipment, in relation to the place of installation, is generally that specified in Tab 2.

4.1.2 Equipment supplied at nominal voltages in excess of 500 V and accessible to non-authorised personnel (e.g. equipment not located in machinery spaces or in locked compartments under the responsibility of the yacht's officers) is to have a degree of protection against touching live parts of at least IP4X.

4.1.3 In addition to the requirements of this sub-article, equipment installed in spaces with an explosion hazard is also subject to the provisions of [10] Sec 2, [7].

4.1.4 The enclosures of electrical equipment for the monitoring and control of watertight doors which are situated below the bulkhead deck are to provide suitable protection against the ingress of water.

In particular, the minimum required degree of protection is to be:

- IPX7 for electric motors, associated circuits and control components
- IPX8 for door position indicators and associated circuit components
- IPX6 for door movement warning signals.

Note 1: The water pressure testing of the enclosures protected to IPX8 is to be based on the pressure that may occur at the location of the component during flooding for a period of 36 hours.

Table 2 : Minimum Degrees of protection

Example of location	Generators	Motors	Transformers	Swichboard and control gear	Instruments	Switches	Luminaires	Accessories
Steering gear room (above floor) and control rooms	I P 22	I P 22	I P 22	I P 22	I P22	I P 22	I P 22	I P 44
Battery rooms							I P 44+(Ex)	
General store; provision rooms		I P 22				I P 44	I P 44	I P 44
Closed navigation bridge		I P 22	I P 22	I P 22	I P22	I P 22	I P 22	I P 22
Dry accommodation space		IP 20	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20
Damp or humid spaces; ventilation pipes and engine room (above floor)	I P 44	I P 44	I P 44	I P 44	I P 44	I P 55	I P 44	I P 55
Engine rooms (below floor) **(1)**		I P X8			I P X8	I P X8	I P X8	
Open deck		I P 56		I P 56	I P 56	I P 56	I P 56	I P 56
(1) Electrical equipment is not to be installed below floor plates in engine rooms, except as indicated above.								

4.1.5

For electrical and electronic equipment installed in engine rooms protected by fixed water-based local application fire-fighting systems

the following applies:

a) The following definitions apply (see also Fig 1):

1) Protected space: a machinery space where a FWBLAFFS is installed.

2) Protected areas: areas within a protected space

which are required to be protected by FWBLAFFS.

3) Adjacent areas:

-areas, other than protected areas, exposed to direct spray

- areas, other than those defined above, where water may extend.

b) The electrical and electronic equipment enclosures located within areas protected by FWBLAFFS and those within adjacent areas exposed to direct spray is to have a degree of protection not less than IP44, except where evidence of suitability is submitted to and approved by the Society.

c) The electrical and electronic equipment within adjacent areas not exposed to direct spray may have a lower degree of protection provided evidence of suitability for use in these areas is submitted taking into account the design and equipment layout, e.g. position of inlet ventilation openings, and that cooling airflow for the equipment is assured.

Note 1: Additional precautions may be required to be taken in respect of:

a) tracking as a result of water entering the equipment

b) potential damage as a result of residual salts from sea water systems

c) high voltage installations

d) personnel protection against electric shock.

4.1.6 Cables entries positioned on top of an enclosure are to be watertight (at least IP55) unless the cable entry plate or cable attachment is made so as to exclude water entry. For other positions, cable entries are to have an IP rating equal to that of the equipment.

5 Diversity (demand) factors

5.1 General

5.1.1 The cables and protective devices of final sub-circuits are to be rated in accordance with their connected load.

5.1.2 Circuits supplying two or more final sub-circuits are to be rated in accordance with the total connected load subject, where justifiable, to the application of a diversity (demand) factor.

5.1.3 A diversity (demand) factor may be applied provided that the known or anticipated operating conditions in a particular part of an installation are suitable for the application of diversity.

6 Electrical protection

6.1 General requirements for overcurrent protection

6.1.1 Electrical installations are to be protected against accidental overcurrents including short-circuit.

The choice, arrangement and performance of the various protective devices are to provide complete and coordinated automatic protection in order to ensure as far as possible:

- continuity of service in the event of a fault, through coordinated and discriminative action of the protective devices
- elimination of the effects of faults to reduce damage to the system and the hazard of fire as far as possible.

Note 1: An overcurrent is a current exceeding the nominal current.

Note 2: A short-circuit is the accidental connection by a relatively low resistance or impedance of two or more points in a circuit which are normally at different voltages.

6.1.2 Devices provided for overcurrent protection are to be chosen according to the requirements, especially with regard to overload and short-circuit.

Note 1: Overload is an operating condition in an electrically undamaged circuit which causes an overcurrent.

6.1.3 Systems are to be such as to withstand the thermal and electrodynamic stresses caused by the possible overcurrent, including short-circuit, for the admissible duration.

6.2 Short-circuit currents

6.2.1 In calculating the maximum prospective short-circuit current, the source of current is to include the maximum number of generators which can be simultaneously connected (as far as permitted by any interlocking arrangements), and the maximum number of motors which are normally simultaneously connected in the system.

The maximum number of generators or transformers is to be evaluated without taking into consideration short-term parallel operation (e.g. for load transfer) provided that suitable interlock is foreseen.

6.2.2 Short-circuit current calculations are to be performed in accordance with a method recognised by the Society, such as that given in IEC Publication 61363-1.

6.2.3 In the absence of precise data concerning the characteristics of generators, accumulator batteries and motors, the maximum short-circuit currents on the main busbars may be calculated as follows:

- for alternating current systems:

  $I_{ac} = 10\ I_{TG} + 3,5\ I_{TM}$

  $I_{pk} = 2,4\ I_{ac}$
- for direct current systems supplied by batteries:

$I_p = K C_{10} + 6 I_{TM}$

where:

I_p : Maximum short-circuit current

I_{ac} : r.m.s. value of the symmetrical component (at the instant T/2)

I_{pk} : Maximum peak value

I_{TG} : Rated current of all generators which can be connected simultaneously

C_{10} : Battery capacity in Ah for a discharge duration of 10 hours

K : Ratio of the short-circuit current of the batteries to C_{10}; (see Note 1)

I_{TM} : Rated current of all motors which are normally simultaneously connected in the system.

Note 1: For stationary batteries the following values may be assumed for guidance:

- vented lead-acid batteries: K = 8
- vented alkaline type batteries intended for discharge at low rates corresponding to a battery duration exceeding three hours: K = 15
- sealed lead-acid batteries having a capacity of 100 Ah or more or alkaline type batteries intended for discharge at high rates corresponding to a battery duration not exceeding three hours: K = 30.

6.3 Selection of equipment

6.3.1

Circuit-breakers are to be suitable for isolation.

Circuit-breakers of withdrawable type are required where they are not suitable for isolation.

6.3.2 Equipment is to be chosen on the basis of its rated current and its making/breaking capacity.

6.3.3

In the selection of circuit-breakers with intentional short-time delay for short-circuit release (e.g. generator circuit-breakers), those of utilisation category B are to be used and they are to be selected also taking into account their rated short-time withstand current capacity (I_{cw}).

For circuit-breakers without intentional short-time delay for short-circuit release, circuit breakers of utilisation category A may be used and they are to be selected according to their rated service short-circuit breaking capacity (I_{cs}).

Note 1: For the purpose of these Rules, circuit breakers are distinguished according to the utilization categories A and B in compliance with IEC publication 60947-2 as follows:

- Utilisation category A: circuit-breakers not specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. without an intentional short-time delay provided for selectivity under short-circuit conditions and therefore without a short-time withstand current rating (Icw).
- Utilisation category B: circuit-breakers specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. with an intentional short-time delay (which may be adjustable) provided for selectivity under short-circuit conditions. Such circuit-breakers have a short-time withstand current rating (Icw).

6.3.4 For duplicated essential services and non-essential services, circuit-breakers may be selected according to their ultimate short-circuit breaking capacity (I_{cu}).

6.3.5

Circuit breakers used in insulated systems are to comply with Annex H of IEC Publication 60947-2.

6.3.6 For switches, the making/breaking capacity is to be in accordance with utilisation category AC-22 A or DC-22 A (in compliance with IEC Publication 60947-3).

6.3.7 For fuse-switch disconnectors or switch-disconnector fuse units, the making/breaking capacity is to be in accordance with utilisation categories AC-23 A or DC-23 A (in compliance with IEC Publication 60947-3).

6.4 Protection against short-circuit

6.4.1 Protection against short-circuit currents is to be provided by circuit- breakers or fuses.

6.4.2 The rated short-circuit breaking capacity of every protective device is to be not less than the maximum prospective value of the short-circuit current at the point of installation at the instant of contact separation.

6.4.3 The rated short-circuit making capacity of every mechanical switching device intended to be capable of being closed 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.

6.4.4 Every protective device or contactor not intended for short-circuit interruption is to be adequate for the maximum short-circuit current liable to occur at the point of installation having regard to the time required for the short-circuit to be removed.

6.4.5 The use of a protective device not having a short-circuit breaking or making capacity at least equal to the maximum prospective short-circuit current at the point where it is installed is permitted, provided that it is backed up on the generator side by a fuse or by a circuit-breaker having at least the necessary short-circuit rating and not being the generator circuit-breaker.

6.4.6 The same fuse or circuit-breaker may back up more than one circuit-breaker where the circuits concerned do not involve essential services.

6.4.7 The short-circuit performance of the back-up arrangement is to be equal to the requirements of IEC Publication 60947-2 for a single circuit-breaker having the same short-circuit performance category as the backed-up circuit-breaker and rated for the maximum prospective short-circuit level at the supply terminals of the arrangement.

6.4.8 Circuit-breakers with fuses connected to the load side may be used, provided the back-up fuses and the circuit-breakers are of coordinated design, in order to ensure that the operation of the fuses takes place in due time so as to prevent arcing between poles or against metal parts of the circuit-breakers when they are submitted to overcurrents involving the operation of the fuse.

6.4.9 When determining the performance requirements for the above-mentioned back-up protection arrangement, it is permissible to take into account the impedance of the various circuit elements of the arrangement, such as the impedance of a cable connection when the backed-up circuit-breaker is located away from the back-up breaker or fuse.

6.5 Continuity of supply and continuity of service

6.5.1 The protection of circuits is to be such that a fault in one service does not cause the loss of any essential services.

6.5.2 The protection of the emergency circuit is to be such that a failure in one circuit does not cause a loss of other emergency services.

Note 1: The continuity of supply for the primary essential services and the continuity of service for the secondary essential services are to be ensured.

The continuity of supply is the condition for which during and after a fault in a circuit, the supply to the healthy circuits (see circuit 3 in Fig 2) is permanently ensured.

The continuity of service is the condition for which after a fault in a circuit has been cleared, the supply to the healthy circuits (see circuit 3 in Fig 2) is re-established.

6.6 Protection against overload

6.6.1 Devices provided for overload protection are to have a tripping characteristic (overcurrent-trip time) adequate for the overload ability of the elements of the system to be protected and for any discrimination requirements.

6.6.2 The use of fuses up to 320 A for overload protection is permitted.

6.7 Localisation of overcurrent protection

6.7.1 Short-circuit protection is to be provided for every non-earthed conductor.

6.7.2 Overload protection is to be provided for every non-earthed conductor; nevertheless, in insulated single-phase circuits or insulated three-phase circuits having substantially balanced loads, the overload protection may be omitted on one conductor.

6.7.3 Short-circuit and overload protective devices are not to interrupt earthed conductors, except in the case of multiple disconnection devices which simultaneously interrupt all the conductors, whether earthed or not.

6.7.4 Electrical protection is to be located as close as possible to the origin of the protected circuit.

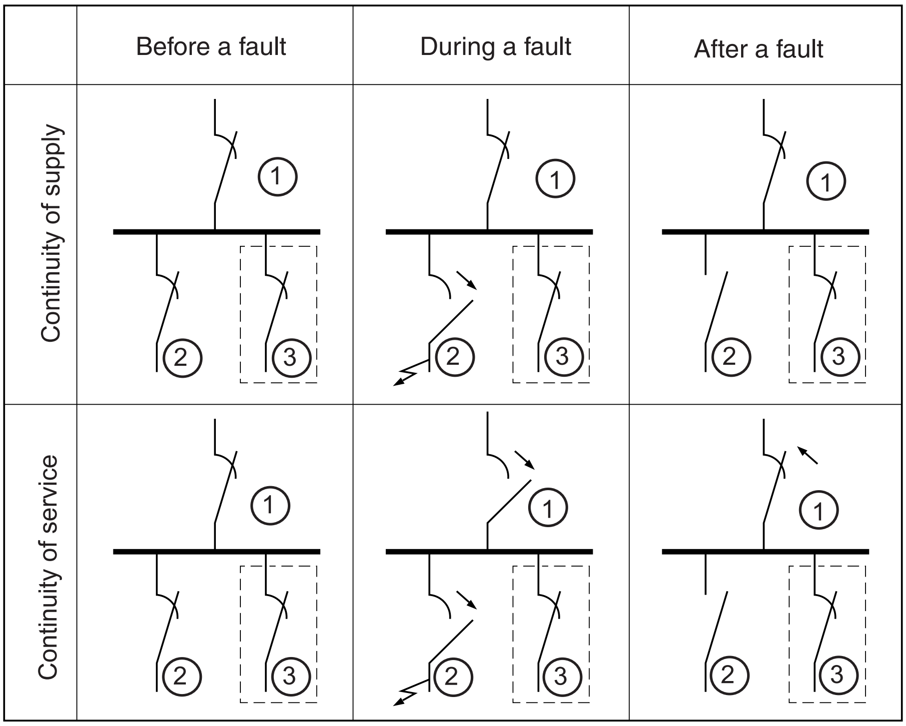
6.8 Protection of generators

6.8.1 Generators are to be protected against short-circuits and overloads by multipole circuit-breakers.

For generators not arranged to operate in parallel with a rated output equal to or less than 50 kVA, a multipole switch with a fuse in each insulated phase on the generator side may be accepted.

6.8.2 When multipole switch and fuses are used, the fuse rating is to be maximum 110% of the generator rated current.

Figure 2



6.8.3 Where a circuit-breaker is used:

a) the overload protection is to trip the generator circuit-breaker at an overload between 10% and 50%; for an overload of 50% of the rated current of the generator the time delay is not to exceed 2 minutes; however, the figure of 50% or the time delay of 2 minutes may be exceeded if the construction of the generator permits this

b) the setting of the short-circuit protection is to instantaneously trip the generator circuit-breaker at an overcurrent less than the steady short-circuit current of the generator. Short time delays (e.g. from 0,5 s to 1 s) may be introduced for discrimination requirements in "instantaneous" tripping devices.

6.8.4 For emergency generators the overload protection may, instead of disconnecting the generator automatically, give a visual and audible alarm in a permanently attended space.

6.8.5 After disconnection of a generator due to overload, the circuit-breaker is to be ready for immediate reclosure.

6.8.6 Generator circuit-breakers are to be provided with a reclosing inhibitor which prevents their automatic reclosure after tripping due to a short-circuit.

6.8.7 Generators having a capacity of 1500 kVA or above are to be equipped with a suitable protective device or system which, in the event of a short-circuit in the generator or in the supply cable between the generator and its circuit-breaker, will de-excite the generator and open the circuit-breaker (e.g. by means of differential protection).

6.8.8 Where the main source of electrical power is necessary for the propulsion of the yacht, load shedding or other equivalent arrangements are to be provided to protect the generators against sustained overload.

6.8.9 Arrangements are to be made to disconnect or reduce automatically the excess load when the generators are overloaded in such a way as to prevent a sustained loss of speed and/or voltage (see Sec 2, Tab 6). The operation of such device is to activate a visual and audible alarm. A time delay of 5-20 s is considered acceptable.

6.8.10 When an overload is detected the load shedding system is to disconnect automatically, after an appropriate time delay, the circuits supplying the non-essential services and, if necessary, the secondary essential services in a second stage.

6.8.11 Alternating current generators arranged to operate in parallel are to be provided with reverse-power protection.

The protection is to be selected in accordance with the characteristics of the prime mover.

The following values are recommended:

- 2-6% of the rated power for turbogenerators
- 8-15% of the rated power for diesel generators.

The reverse-power protection may be replaced by other devices ensuring adequate protection of the prime movers.

6.8.12 Generators are to be provided with an undervoltage protection which trips the breaker if the voltage falls to 70% - 35% of the rated voltage.

For generators arranged for parallel operation, measures are to be taken to prevent the generator breaker from closing if the generator is not generating and to prevent the generator remaining connected to the busbars if voltage collapses.

The operation of the undervoltage release is to be instantaneous when preventing closure of the breaker, but it is to be delayed for selectivity purposes when tripping the breaker.

6.9 Protection of circuits

6.9.1 Each separate circuit shall be protected against short-circuit and against overload, unless otherwise specified in these Rules or where the Society may exceptionally otherwise permit.

6.9.2 Each circuit is to be protected by a multipole circuit-breaker or switch and fuses against overloads and short-circuits.

6.9.3 Circuits for lighting are to be disconnected on both non-earthed conductors; single-pole disconnection of final sub-circuits with both poles insulated is permitted only in accommodation spaces.

6.9.4 The protective devices of the circuits supplying motors are to allow excess current to pass during transient starting of motors.

6.9.5 Final sub-circuits which supply one consumer with its own overload protection (for example motors), or consumers which cannot be overloaded (for example permanently wired heating circuits and lighting circuits), may be provided with short-circuit protection only.

6.9.6 Steering gear circuits are to be provided with short-circuit protection only (see Ch 1, Sec 11, [2]).

6.10 Protection of motors

6.10.1 Motors of rating exceeding 1 kW and all motors for essential services are to be protected individually against overload and short-circuit. The short-circuit protection may be provided by the same protective device for the motor and its supply cable (see [6.9.5]).

6.10.2 For motors intended for essential services, the overload protection may be replaced by an overload alarm (for steering gear motors see Ch 1, Sec 11, [2]).

6.10.3 The protective devices are to be designed so as to allow excess current to pass during the normal accelerating period of motors according to the conditions corresponding to normal use.

If the current/time characteristic of the overload protection device does not correspond to the starting conditions of a motor (e.g. for motors with extra-long starting period), provision may be made to suppress operation of the device during the acceleration period on condition that the short-circuit protection remains operative and the suppression of overload protection is only temporary.

6.10.4 For continuous duty motors the protective gear is to have a time delay characteristic which ensures reliable thermal protection against overload.

6.10.5 The protective devices are to be adjusted so as to limit the maximum continuous current to a value within the range 105% - 120% of the motor’s rated full load current.

6.10.6 For intermittent duty motors the current setting and the delay (as a function of time) of the protective devices are to be chosen in relation to the actual service conditions of the motor.

6.10.7 Where fuses are used to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overload in the case of single phasing.

6.10.8 Motors rated above 1 kW are to be provided with:

- undervoltage protection, operative on the reduction or failure of voltage, to cause and maintain the interruption of power in the circuit until the motor is deliberately restarted or
- undervoltage release, operative on the reduction or failure of voltage, so arranged that the motor restarts automatically when power is restored after a power failure.

6.10.9 The automatic restart of a motor is not to produce a starting current such as to cause excessive voltage drop.

In the case of several motors required to restart automatically, the total starting current is not to cause an excessive voltage drop or sudden surge current; to this end, it may be necessary to achieve a sequence start.

6.10.10 The undervoltage protective devices are to allow the motor to be started when the voltage exceeds 85% of the rated voltage and are to intervene without fail when the voltage drops to less than approximately 20% of the rated voltage, at the rated frequency and with a time delay as necessary.

6.11 Protection of storage batteries

6.11.1 Batteries are to be protected against overload and short-circuit by means of fuses or multipole circuit-breakers at a position adjacent to the battery compartment.

Overcurrent protection may be omitted for the circuit to the starter motors when the current drawn is so large that is impracticable to obtain short-circuit protection.

6.11.2 Emergency batteries supplying essential services are to have short-circuit protection only.

6.12 Protection of shore power connection

6.12.1 Permanently fixed cables connecting the shore connection box to the main switchboard are to be protected by fuses or circuit-breakers (see [3.8.4]).

6.13 Protection of measuring instruments, pilot lamps and control circuits

6.13.1 Measuring circuits and devices (voltage transformers, voltmeters, voltage coils of measuring instruments, insulation monitoring devices etc.) and pilot lamps are to be protected against short-circuit by means of multipole circuit-breakers or fuses.

The protective devices are to be placed as near as possible to the tapping from the supply.

The secondary side of current transformers is not to be protected.

6.13.2 Control circuits and control transformers are to be protected against overload and short-circuit by means of multipole circuit-breakers or fuses on each pole not connected to earth.

Overload protection may be omitted for transformers with a rated current of less than 2 A on the secondary side.

The short-circuit protection on the secondary side may be omitted if the transformer is designed to sustain permanent short-circuit current.

6.13.3 Where a fault in a pilot lamp would impair the operation of essential services, such lamps are to be protected separately from other circuits such as control circuits.

Note 1: Pilot lamps connected via short-circuit-proof transformers may be protected in common with control circuits.

6.13.4 Circuits whose failure could endanger operation, such as steering gear control feeder circuits, are to be protected only against short-circuit.

6.13.5 The protection is to be adequate for the minimum cross-section of the protected circuits.

6.14 Protection of transformers

6.14.1 The primary winding side of power transformers is to be protected against short-circuit and overload by means of multipole circuit-breakers or switches and fuses.

Overload protection on the primary side may be dispensed with where it is provided on the secondary side or when the total possible load cannot reach the rated power of the transformer.

6.14.2 The protection against short-circuit is to be such as to ensure the selectivity between the circuits supplied by the secondary side of the transformer and the feeder circuit of the transformer.

6.14.3 When transformers are arranged to operate in parallel, means are to be provided so as to trip the switch on the secondary winding side when the corresponding switch on the primary side is open.

7 System components

7.1 General

7.1.1 The components of the electrical system are to be dimensioned such as to withstand the currents that can pass through them during normal service without their rating being exceeded.

7.1.2 The components of the electrical system are to be designed and constructed so as to withstand for the admissible duration the thermal and electrodynamic stresses caused by possible overcurrents, including short-circuit.

8 Electrical cables

8.1 General

8.1.1 All electrical cables and wiring external to equipment shall be at least of a flame-retardant type, in accordance with IEC Publication 60332-1.

8.1.2 In addition to the provisions of [8.1.1], when cables are laid in bundles, cable types are to be chosen in compliance with IEC Publication 60332-3 Category A, or other means (see Sec 12) are to be provided such as not to impair their original flame-retarding properties.

8.1.3 Where necessary for specific applications such as radio frequency or digital communication systems, which require the use of particular types of cables, the Society may permit the use of cables which do not comply with the provisions of [8.1.1] and [8.1.2].

8.1.4
Cables which are required to have fire-resisting characteristics are to comply with the requirements stipulated in [8.6].

8.2 Choice of insulation

8.2.1 The maximum rated operating temperature of the insulating material is to be at least 10°C higher than the maximum ambient temperature liable to occur or to be produced in the space where the cable is installed.

8.2.2 The maximum rated conductor temperature for normal and short-circuit operation, for the type of insulating compounds normally used for board cables, is not to exceed the values stated in Tab 3. Special consideration will be given to other insulating materials.

8.2.3 PVC insulated cables are not to be used either in refrigerated spaces, or on decks exposed to the weather of yachts classed for unrestricted service.

8.2.4 Mineral insulated cables will be considered on a case by case basis.

8.3 Choice of protective covering

8.3.1 The conductor insulating materials are to be enclosed in an impervious sheath of material appropriate to the expected ambient conditions where cables are installed in the following locations:

- on decks exposed to the weather,
- in damp or wet spaces (e.g. in bathrooms),
- in refrigerated spaces,
- in machinery spaces and, in general,
- where condensation water or harmful vapour may be present.

8.3.2 Where cables are provided with armour or metallic braid (e.g. for cables installed in hazardous areas), an overall impervious sheath or other means to protect the metallic elements against corrosion is to be provided; see Sec 9, [1.5].

8.3.3 An impervious sheath is not required for single-core cables installed in tubes or ducts inside accommodation spaces, in circuits with maximum system voltage 250 V.

8.3.4 In choosing different types of protective coverings, due consideration is to be given to the mechanical action to which each cable may be subjected during installation and in service.

If the mechanical strength of the protective covering is considered insufficient, the cables are to be mechanically protected (e.g. by an armour or by installation inside pipes or conduits).

8.3.5 Single-core cables for a.c. circuits with rated current exceeding 20 A are to be either non-armoured or armoured with non-magnetic material.

8.4 Cables in refrigerated spaces

8.4.1 Cables installed in refrigerated spaces are to have a watertight or impervious sheath and are to be protected against mechanical damage. If an armour is applied on the sheath, the armour is to be protected against corrosion by a further moisture-resisting covering.

8.5 Cables in areas with a risk of explosion

8.5.1 For cables in areas with a risk of explosion, see [10].

8.6 Electrical services required to be operable under fire conditions and fire-resistant cables

8.6.1

Electrical services required to be operable under fire conditions are as follows:

- Control and power systems to power-operated fire doors and status indication for all fire doors
- Control and power systems to power-operated watertight doors and their status indication
- Emergency fire pump
- Emergency lighting
- Fire and general alarms
- Fire detection systems
- Fire-extinguishing systems and fire-extinguishing media release alarms
- Low location lighting
- Public address systems
- Remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and/or explosion.

8.6.2

Where cables for services specified in [9.6.1] including their power supplies pass through high fire risk areas (see Note 1), other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone. This may be achieved by either of the following measures:

a) Cables being of a fire-resistant type complying with IEC 60331-1 for cables of greater than 20 mm overall diameter, otherwise IEC 60331-21 or IEC 60331-2 for cables with an overall diameter not exceeding 20 mm, are installed and run continuous to keep the fire integrity within the high fire risk area (see Fig 3).

b) At least two loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.

Systems that are, fail safe or duplicated with cable runs as widely separated as is practicable may be exempted.

Note 1:

a) For the purpose of application of this item [9.6], the definition of "high fire risk areas" is the following:

(1) Machinery spaces as defined by Chapter 4 Sec 1

(2) Spaces containing fuel treatment equipment and other highly flammable substances

(3) Galley and Pantries containing cooking appliances

(4) Laundry containing drying equipment

b) Fire-resistant type cables are to be easily distinguishable.

c) For special cables, requirements in the following standards may be used:

(1) IEC60331-23: Procedures and requirements - Electric data cables

(2) IEC60331-25: Procedures and requirements - Optical fibre cables.

8.6.3

The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps and their source(s) of power and prime mover(s).

They are to be of a fire resistant type, in accordance with [8.6.2] a), where they pass through other high fire risk areas.

8.7 Cables for submerged bilge pumps

8.7.1 Cables and their connections to such pumps are to be capable of operating under a head of water equal to their distance below the bulkhead deck. The cable is to be impervious-sheathed and armoured, is to be installed in continuous lengths from above the bulkhead to the motor terminals and is to enter the air bell from the bottom.

8.8 Internal wiring of switchboards and other enclosures for equipment

8.8.1 For installation in switchboards and other enclosures for equipment, single-core cables may be used without further protection (sheath).

Other types of flame-retardant switchboard wiring may be accepted at the discretion of the Society.

8.9 Current carrying capacity of cables

8.9.1 The current carrying capacity for continuous service of cables given in Tab 4 to Tab 8 is based on the maximum permissible service temperature of the conductor also indicated therein and on an ambient temperature of 45°C.

8.9.2 The current carrying capacity cited in [9.9.1] is applicable, with rough approximation, to all types of protective covering (e.g. both armoured and non-armoured cables).

8.9.3 Values other than those shown in Tab 4 to Tab 8 may be accepted provided they are determined on the basis of calculation methods or experimental values approved by the Society.

8.9.4 When the actual ambient temperature obviously differs from 45°C, the correction factors shown in Tab 9 may be applied to the current carrying capacity in Tab 4 to Tab 8.

8.9.5 Where more than six cables are bunched together in such a way that there is an absence of free air circulating around them, and the cables can be expected to be under full load simultaneously, a correction factor of 0,85 is to be applied.

Figure 3

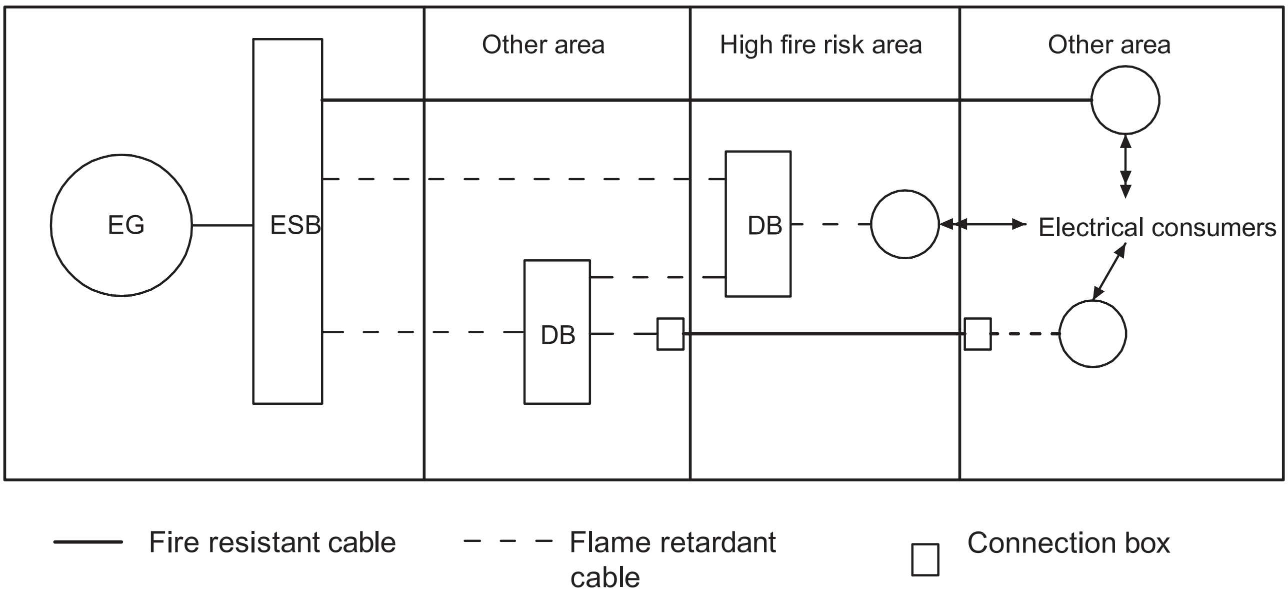


Table 3 : Maximum rated conductor temperature *(1/1/2025)*

Type of insulating compound	Abbreviated designation	Maximum rated conductor temperature, in °C	
		Normal operation	Short-circuit
a) Thermoplastic:			
- based upon polyvinyl chloride or copolymer of vinyl chloride and vinyl acetate	PVC	70	150
b) Elastomeric or thermosetting:			
- based upon ethylene-propylene rubber or similar (EPM or EPDM)	EPR	90	250
- based upon high modulus or hardgrade ethylene propylene rubber	HEPR	90	250
- based upon cross-linked polyethylene	XLPE	90	250
- based upon rubber silicon	S 95	95	350(2)
- based upon ethylene-propylene rubber or similar (EPM or EPDM) halogen free	HF EPR	90	250 (2)
- based upon high modulus or hardgrade halogen free ethylene propylene rubber	HF HEPR	90	250
- based upon cross-linked polyethylene halogen free	HF XLPE	90	250
- based upon rubber silicon halogen free	HF S 95	95	350
- based upon cross-linked polyolefin material for halogen free cable **(1)**	HF 90	90	250
(1) Used on sheathed cable only			
(2) This temperature is applicable only to power cables and not appropriate for tinned copper conductors			

Table 4 : Current carrying capacity, in A in continuous service for cables based on maximum conductor operating temperature of 60°C (ambient temperature 45°C) *(1/1/2025)*

Nominal section mm^2	Number of conductors		
	1	2	3 or 4
1,5	10	9	7
2,5	17	14	12
4	232	20	16
6	29	25	20
10	40	34	28
16	54	46	38
25	71	60	50
35	88	75	62
50	110	94	77
70	135	115	95
95	164	139	115
120	189	161	132
150	218	185	153
185	248	211	174
240	292	248	204
300	336	286	235
400	d.c.:390 a.c.:380	d.c.:332 a.c.:323	d.c.:273 a.c.:266
500	d.c.:450 a.c.:430	d.c.:383 a.c.:366	d.c.:315 a.c.:301
600	d.c.:520 a.c.:470	d.c.:442 a.c.:400	d.c.:364 a.c.:329

Table 5 : Current carrying capacity, in A in continuous service for cables based on maximum conductor operating temperature of 70°C (ambient temperature 45°C) *(1/1/2025)*

Nominal section mm²	Number of conductors		
	1	2	3 or 4
1,5	15	13	11
2,5	21	18	15
4	29	25	20
6	37	31	26
10	51	43	36
16	68	58	48
25	90	77	63
35	111	94	78
50	138	117	97
70	171	145	120
95	207	176	145
120	239	203	167
150	275	234	193
185	313	266	219
240	369	314	258
300	424	360	297
400	d.c.:500 a.c.:490	d.c.:425 a.c.:417	d.c.:350 a.c.:343
500	d.c.:580 a.c.:550	d.c.:493 a.c.:468	d.c.:406 a.c.:385
600	d.c.:670 a.c.:610	d.c.:570 a.c.:519	d.c.:467 a.c.:427

Table 6 : Current carrying capacity, in A in continuous service for cables based on maximum conductor operating temperature of 85°C (ambient temperature 45°C) *(1/1/2025)*

Nominal section mm²	Number of conductors		
	1	2	3 or 4
1,5	21	8	5
2,5	28	24	20
4	38	32	27
6	49	42	34
10	67	57	47
16	91	77	64
25	120	102	84
35	148	126	104
50	184	156	129
70	228	194	160
95	276	235	193
120	319	271	223
150	367	312	257
185	418	355	293
240	492	418	344
300	565	408	396

Nominal section mm^2	Number of conductors		
	1	2	3 or 4
400	d.c.:650 a.c.:630	d.c.:553 a.c.:536	d.c.:455 a.c.:441
500	d.c.:740 a.c.:680	d.c.:629 a.c.:578	d.c.:518 a.c.:476
600	d.c.:840 a.c.:740	d.c.:714 a.c.:629	d.c.:588 a.c.:518

Table 7 : Current carrying capacity, in A in continuous service for cables based on maximum conductor operating temperature of 90°C (ambient temperature 45°C) *(1/1/2025)*

Nominal section mm^2	Number of conductors		
	1	2	3 or 4
1,5	23	20	16
2,5	40	26	21
4	51	34	28
6	52	44	36
10	72	16	50
16	96	82	67
25	127	108	89
35	157	133	110
50	196	167	137
70	242	206	169
95	293	249	205
120	339	288	237
150	389	331	272
185	444	377	311
240	522	444	365
300	601	511	421
400	d.c.:690 a.c.:670	d.c.:587 a.c.:570	d.c.:483 a.c.:469
500	d.c.:780 a.c.:720	d.c.:663 a.c.:612	d.c.:546 a.c.:504
600	d.c.:890 a.c.:780	d.c.:757 a.c.:663	d.c.:623 a.c.:546

Table 8 : Current carrying capacity, in A in continuous service for cables based on maximum conductor operating temperature of 95°C (ambient temperature 45°C) *(1/1/2025)*

Nominal section mm^2	Number of conductors		
	1	2	3 or 4
1,5	26	22	18
2,5	32	27	22
4	43	37	30
6	55	47	39
10	76	65	53
16	102	87	71
25	135	115	95
35	166	141	116

Nominal section mm^2	Number of conductors		
	1	2	3 or 4
50	208	177	140
70	256	218	179
95	310	264	217
120	359	305	251
150	412	350	288
185	470	400	329
240	535	470	387
300	636	541	445
400	d.c.:760 a.c.:725	d.c.:646 a.c.:616	d.c.:532 a.c.:508
500	d.c.:875 a.c.:810	d.c.:744 a.c.:689	d.c.:612 a.c.:567
600	d.c.:1010 a.c.:900	d.c.:859 a.c.:765	d.c.:707 a.c.:630

8.9.6 Where a cable is intended to supply a short-time load for 1/2-hour or 1-hour service (e.g. mooring winches or bow thruster propellers), the current carrying capacity obtained from Tab 4 to Tab 8 may be increased by applying the corresponding correction factors given in Tab 10.

In no case is a period shorter than 1/2-hour to be used, whatever the effective period of operation.

8.9.7 For supply cables to single services for intermittent loads, the current carrying capacity obtained from Tab 4 to Tab 8 may be increased by applying the correction factors given in Tab 11.

The correction factors are calculated with rough approximation for periods of 10 minutes, of which 4 minutes with a constant load and 6 minutes without load.

8.10 Minimum nominal cross-sectional area of conductors

8.10.1 In general the minimum allowable conductor cross-sectional areas are those given in Tab 12.

8.10.2 The nominal cross-sectional area of the neutral conductor in three-phase distribution systems is to be equal to at least 50% of the cross-sectional area of the phases, unless the latter is less than or equal to 16 mm^2. In such case the cross-sectional area of the neutral conductor is to be equal to that of the phase.

8.10.3 For the nominal cross-sectional area of:

- earthing conductors, see Sec 12, [2.3]
- earthing connections for distribution systems, see Sec 12, [2.5].

8.11 Choice of cables

8.11.1 The rated voltage of any cable is to be not lower than the nominal voltage of the circuit for which it is used.

8.11.2 The nominal cross-sectional area of each cable is to be sufficient to satisfy the following conditions with reference to the maximum anticipated ambient temperature:

- the current carrying capacity is to be not less than the highest continuous load carried by the cable
- the voltage drop in the circuit, by full load on this circuit, is not to exceed the specified limits
- the cross-sectional area calculated on the basis of the above is to be such that the temperature increases which may be caused by overcurrents or starting transients do not damage the insulation.

8.11.3 The highest continuous load carried by a cable is to be calculated on the basis of the power requirements and of the diversity factor of the loads and machines supplied through that cable.

8.11.4 When the conductors are carrying the maximum nominal service current, the voltage drop from the main or emergency switchboard busbars to any point in the installation is not to exceed 6% of the nominal voltage.

For battery circuits with supply voltage less than 55 V, this value may be increased to 10%.

For the circuits of navigation lights, the voltage drop is not to exceed 5% of the rated voltage under normal conditions.

Table 9 : Correction factors for various ambient air temperatures (Reference ambient temperature of 45°C)
(1/1/2025)

Maximum conductor temperature, in °C	Correction factors for ambient air temperature of :										
	35°C	40°C	45°C	50°C	55°C	60°C	65°C	70°C	75°C	80°C	85°C
60	1,29	1,15	1,00	0,82	-	-	-	-	-	-	-
65	1.22	1.12	1.00	0.87	0.71	-	-	-	-	-	-
70	1.18	1.10	1.00	0.89	0.77	0.63	-	-	-	-	-
75	1,15	1,08	1,00	0,91	0,82	0,71	0,58	-	-	-	-
80	1,13	1,07	1,00	0,93	0,85	0,76	0,65	0,53	-	-	-
85	1,12	1,06	1,00	0,94	0,87	0,79	0,71	0,61	0,50	-	-
90	1.10	1.05	1.00	0.94	0.88	0.82	0.74	0.67	0.58	0.47	-
95	1,10	1,05	1,00	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

Table 10 : Correction factors for short-time loads

½ -hour service		1-hour service		
Sum of nominal cross-sectional areas of all conductors in the cable, in mm²		Sum of nominal cross-sectional areas of all conductors in the cable, in mm²		Correlation factor
Cables with metallic sheath and armoured cables	Cables with non-metallic sheath and non-armoured cables	Cables with metallic sheath and armoured cables	Cables with non-metallic sheath and non-armoured cables	
up to 20	up to 75	up to 80	up to 230	1,06
21-41	76-125	81-170	231-400	1,10
41-65	126-180	171-250	401-600	1,15
66-95	181-250	251-430	601-800	1,20
96-135	251-320	431-600	-	1,25
136-180	321-400	601-800	-	1,30
181-235	401-500	-	-	1,35
236-285	501-600	-	-	1,40
286-350	-	-	-	1,45

Table 11 : Correction factors for intermittent service

Sun of nominal cross selectionel areas of all conductors in the cable, in mm²		Correction factor
Cables with metallic sheath and armoured cables	Cables without metallic sheath and non-amoured cables	
	$S \leq 5$	1,10
	$5 < S \leq 8$	1,15
	$8 < S \leq 16$	1,20
$S \leq 4$	$16 < S \leq 825$	1,25
$4 < S \leq 7$	$25 < S \leq 42$	1,30
$7 < S \leq 17$	$42 < S \leq 72$	1,35
$17 < S \leq 42$	$72 < S \leq 140$	1,40
$42 < S \leq 110$	$140 < S$	1,45
$110 < S$	-	1,50

8.11.5 T9.11.4 Cables with conductors of cross-section less than 10 mm^2 are not to be connected in parallel.

9 Electrical installations in hazardous areas

9.1 Electrical equipment

9.1.1 No electrical equipment is to be installed in hazardous areas unless the Society is satisfied that such equipment is:

- essential for operational purposes,
- of a type which will not ignite the mixture concerned,
- appropriate to the space concerned, and
- appropriately certified for safe usage in the dusts, vapours or gases likely to be encountered.

9.1.2 Where electrical equipment of a safe type is permitted in hazardous areas it is to be selected with due consideration to the following:

a) risk of explosive dust concentration; see Sec 2, [6.2]:
   - degree of protection of the enclosure
   - maximum surface temperature

b) risk of explosive gas atmosphere; see Sec 2, [6.1]:
   - explosion group
   - temperature class.

9.1.3 Where electrical equipment is permitted in hazardous areas, all switches and protective devices are to interrupt all poles or phases and, where practicable, to be located in a non-hazardous area unless specifically permitted otherwise.

Such switches and equipment located in hazardous areas are to be suitably labelled for identification purposes.

9.1.4 For electrical equipment installed in Zone 0 hazardous areas, only the following types are permitted:

- certified intrinsically-safe apparatus Ex(ia)
- simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically-safe circuits of category “ia” not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules, and accepted by the appropriate authority
- equipment specifically designed and certified by the appropriate authority for use in Zone 0.

Table 12 : Minimum nominal cross-sectional areas

Service	Nominal cross-sectional area	
	external wiring mm^2	internal wiring mm^2
Power, heating and lighting systems	1,0	1,0
Control circuits for power plant	1,0	1,0
Control circuits other than those for power plant	0,75	0,5
Control circuits for telecommunications, measurement, alarms	0,5	0,2
Telephone and bell equipment, not required for the safety of the or crew calls	0,2	0,1
Bus and data cables	0,2	0,1

9.1.5 For electrical equipment installed in Zone 1 hazardous areas, only the following types are permitted:

- any type that may be considered for Zone 0
- certified intrinsically-safe apparatus Ex(ib)
- simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically-safe circuits of category “ib” not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules, and accepted by the appropriate authority
- certified flameproof Ex(d)
- certified pressurised Ex(p)

- certified increased safety Ex(e)
- certified encapsulated Ex(m)
- certified sand filled Ex(q)
- certified specially Ex(s)
- through runs of cable.

9.1.6

For electrical equipment installed in Zone 2 hazardous areas, only the following types are permitted:

- any type that may be considered for Zone 1
- tested specially for Zone 2 (e.g. type “n” protection)
- pressurised, and accepted by the appropriate authority
- encapsulated, and accepted by the appropriate authority
- the type which ensures the absence of sparks and arcs and of “hot spots” during its normal operation (electrical equipment having an enclosure of at least IP55).

9.1.7 When apparatus incorporates a number of types of protection, it is to be ensured that all are suitable for use in the zone in which it is located.

9.1.8 Electrical equipment which is intended for use in explosive gas atmospheres or which is installed where flammable gases, va-pours or explosive dusts are liable to accumulate, such as in spaces containing petrol-powered machinery, petrol fuel tank(s), or joint fitting(s) or other connections between components of a petrol system, and in compartments or lockers containing LPG cylinders and or pressure regulators, is to conform to IEC 60079 series or equivalent standard

9.2 Electrical cables

9.2.1 Electrical cables are not to be installed in hazardous areas except as specifically permitted or when associated with intrinsically safe circuits.

9.2.2

All cables installed in Zone 0, Zone 1 and weather exposed areas classified Zone 2 are to be sheathed with at least one of the following:

a) a non-metallic impervious sheath in combination with braiding or other metallic covering

b) a copper or stainless steel sheath (for mineral insulated cables only).

9.2.3 All cables installed in non-weather exposed Zone 2 areas are to be provided with at least a non-metallic external impervious sheath.

9.2.4 Cables of intrinsically safe circuits are to have a metallic shielding with at least a non-metallic external impervious sheath.

9.2.5 The circuits of a category “ib” intrinsically safe system are not to be contained in a cable associated with a category “ia” intrinsically safe system required for a hazardous area in which only category “ia” systems are permitted.

9.3 Electrical installations in battery rooms

9.3.1

Only intrinsically safe apparatus and certified safe type lighting fittings may be installed in compartments assigned solely to large vented storage batteries; see Sec 11, [6.2.1].

The associated switches are to be installed outside such spaces.

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.

Overcurrent protective devices are to be installed as close as possible to, but outside of, battery rooms.

Electrical cables other than those pertaining to the equipment arranged in battery rooms are not permitted.

Electrical equipment for use in battery rooms is to have minimum explosion group IIC and temperature class T1.

9.3.2 Standard marine electrical equipment may be installed in compartments assigned solely to valve-regulated sealed storage batteries.

9.3.3

Where vented (see Note 1) type batteries replace valve-regulated sealed (see Note 2) types, the requirements of Sec 11 are to be complied with.

Note 1: A vented battery is one in which the cells have a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere.

Note 2: A valve-regulated battery is one in which cells are closed but have an arrangement (valve) which allows the escape of gas if the internal pressure exceeds a predetermined value.

9.4 Electrical installation in enclosed spaces and lockers containing fuel or flammable liquids having a flash point not exceeding 60°C or vehicle with fuel in their tanks

9.4.1 In enclosed spaces, garages and larger lockers in which vehicles or craft with fuel in their tanks having a flash point not exceeding 60°C are carried and on lockers storing such fuel in which explosive vapours might be expected to accumulate, electrical equipment and cables are to be installed at least 450 mm above the deck (to be regarded as hazardous area ZONE 2). Electrical equipment is to be as stated in [9.1.6] and electrical cables as stated in [9.2.3].

9.4.2

Where the installation of electrical equipment and cables at less than 450 mm above the deck (to be regarded as hazardous area ZONE 1) is deemed necessary for the safe operation of the yacht, the electrical equipment is to be of a certified safe type as stated in [9.1.5] and the electrical cables are to be as stated in [9.2.2].

9.4.3 Electrical equipment and cables in exhaust ventilation ducts are to be as stated in [9.4.2].

9.4.4 For alternative fuelled vehicles, including those battery powered, the adoption of additional measures maybe necessary upon the results of a dedicated risk assessment.

9.5 Underwater lights and similar items (i.e. echo-sound, speed-log ....) *(1/1/2025)*

9.5.1 The lights or similar items to be installed through the outer hull of yachts, placed in a position such that the lower margin of the light is lower than 500 mm above the lower summer load line, are to have the following minimum degree of protection in accordance with IEC Publication 60529 or another equivalent standard:

- IP68 for the external part
- IP67 for the internal part.

The lights or similar items to be installed through the outer hull of yachts, placed in a position such that the lower margin of the light is higher than 500 mm above the lower summer load line, but below the freeboard deck, are to have a minimum degree of protection IP56 in accordance with IEC Publication 60529

9.5.2 Where lights or similar items are installed in spaces where flammable gas or vapours are liable to accumulate (i.e. gasoline engine compartments, etc), the lights are to be certified "safe type electrical equipment" suitable for Zone 1 according to 60079 series.

9.5.3 Constructional drawings of the lights or the items, including materials and characteristics of all components are to be submitted for examination..

9.5.4 The underwater lights or similar items have to be tested at a pressure of at least 4 times the pressure corresponding to the intended location.

9.5.5 Underwater lights and similar items are to be type approved. Tests are to be carried out to verify the degree of protection; pressure test and duration of the test to verify degree of protection IP68 are to be agreed with the Maker taking into account the working condition of the lights (i.e. the depth and the position on the submerged part of the hull). The type approval certificate, having a validity of 5 years, will be issued by Tasneef after examination of the relevant test reports.

10 Recording of the Type, Location and Maintenance Cycle of Batteries

10.1 Battery schedule

10.1.1

Where batteries are fitted for use for essential and emergency services, a schedule of such batteries is to be compiled and maintained. The schedule, required in Sec 1, Tab 1, is to include at least the following information regarding the battery(ies):

- type and Manufacturer's type designation
- voltage and ampere-hour rating
- location
- equipment and/or system(s) served
- maintenance/replacement cycle dates
- date(s) of last maintenance and/or replacement
- for replacement batteries in storage, the date of manufacture and shelf life.

Note 1: Shelf life is the duration of storage under specified conditions at the end of which a battery retains the ability to give a specified performance.

SECTION 4 ROTATING MACHINES

1 Constructional and operational requirements for generators and motors

1.1 Mechanical construction

1.1.1

Insulating materials, insulated windings and construction of electrical machines are to conform to the relevant requirements of Sec 2, [4] and Sec 2, [5].

1.1.2 Shafts are to be made of material complying with the provisions of Pt D, Ch 2, Sec 3 or, where rolled products are allowed in place of forgings, with those of Pt D, Ch 2, Sec 1.

1.1.3 Where welded parts are foreseen on shafts and rotors, the provisions of Part D, Chapter 5 are to apply.

1.1.4 Sleeve bearings are to be efficiently and automatically lubricated at all running speeds.

Provision is to be made for preventing the lubricant from gaining access to windings or other insulated or bare current carrying parts.

1.1.5 Means are to be provided to prevent bearings from being damaged by the flow of currents circulating between them and the shaft. According to the Manufacturer's requirements, electrical insulation of at least one bearing is to be considered.

1.1.6 For surface-cooled machines with an external fan installed on the open deck, adequate protection of the fan against icing is to be provided.

1.1.7 When liquid cooling is used, the coolers are to be so arranged as to avoid entry of water into the machine, whether by leakage or condensation in the heat exchanger, and provision is to be made for the detection of leakage.

1.1.8

Motors cooled with a water jacket can be accepted for both propulsion and auxiliary services, however the use of water jacket cooled electric motors for propulsion is limited to installations with motor redundancy.

In motors cooled with a water jacket, internal water leakage sensors are to be provided.

The water jacket is to be pressure tested at not less than 1,5 times the working pressure after final machining.

1.1.9 Rotating machines whose ventilation or lubrication system efficiency depends on the direction of rotation are to be provided with a warning plate.

1.2 Sliprings, commutators and brushes

1.2.1 Sliprings and commutators with their brushgear are to be so constructed that undue arcing is avoided under all normal load conditions.

1.2.2 The working position of brushgear is to be clearly and permanently marked.

1.2.3 Sliprings, commutators and brushgear are to be readily accessible for inspection, repairs and maintenance.

1.3 Terminal connectors

1.3.1 Suitable, fixed terminal connectors are to be provided in an accessible position for connection of the external cables.

1.3.2 All terminal connectors are to be clearly identified with reference to a diagram.

1.3.3 The degree of protection of terminal boxes is to be adequate to that of the machine.

1.4 Electrical insulation

1.4.1 Insulating materials for windings and other current carrying parts are to comply with the requirements of Sec 2, [4.2] and Sec 2, [4.3].

2 Special requirements for generators

2.1 Prime movers, speed governors and overspeed protection

2.1.1 Prime movers for generators are to comply with the relevant requirements of Ch 1, Sec 2, [4.7].

2.1.2 When generators are to operate in parallel, the characteristics of speed governors are to comply with the provisions of [2.2].

2.2 A.c. generators

2.2.1 Alternators are to be so constructed that, when started up, they take up the voltage without the aid of an external electrical power source.

Where these provisions are not complied with, the external electrical power source is to be constituted by a battery installation in accordance with the requirements for electrical starting systems of auxiliary machinery (see Ch 1, Sec 2).

2.2.2 The voltage wave form is to be approximately sinusoidal, with a maximum deviation from the sinusoidal fundamental curve of 5% of the peak value.

2.2.3 Each alternator is to be provided with automatic means of voltage regulation.

2.2.4 For a.c. generating sets operating in parallel, the governing characteristics of the prime movers are to be such that, within the limits of 20% and 100% total load, the load on any generating set will not normally differ from its proportionate share of the total load by more than 15% of the rated power in kW of the largest machine or 25% of the rated power in kW of the individual machine in question, whichever is the lesser.

2.2.5 For a.c. generating sets intended to operate in parallel, means are to be provided to regulate the governor so as to permit an adjustment of load not exceeding 5% of the rated load at normal frequency.

2.2.6 When a.c. generators are operated in parallel, the reactive loads of the individual generating sets are not to differ from their proportionate share of the total reactive load by more than 10% of the rated reactive power of the largest machine, or 25% of that of the smallest machine, whichever is the lesser.

3 Testing of rotating machines

3.1 General

3.1.1

All machines are to be tested by the Manufacturer

3.1.2

Manufacturer’s test records are to be provided for machines for essential services, for other machines they are to be available upon request.

3.1.3

All tests are to be carried out according to IEC 60092-301.

3.1.4

When required according to Part A Ch.2 App. 3 all a.c. generators having rated power of 100 kVA and above, all d.c. generators having rated power of 100 kW and above, and all a.c./d.c. motors having rated power of 100 kW and above, intended for essential services are to be surveyed by the Society during testing and, if appropriate, during manufacturing.

Note 1: An Alternative Certification Scheme may be agreed by the Society with the Manufacturer whereby the attendance of the Surveyor will not be required as indicated above.

3.2 Shaft material

3.2.1

Shaft material for electric propulsion motors and for main engine driven generators where the shaft is part of the propulsion shafting is to be certified by the Society.

3.2.2

Shaft material for other machines is to be in accordance with recognised international or national standards (See [1.1.2]).

3.3 Tests

3.3.1

Type tests are to be carried out on a prototype machine or on the first of a batch of machines, and routine tests carried out on subsequent machines in accordance with Tab 1.

Note 1: Test requirements may differ for shaft generators, special purpose machines and machines of novel construction.

Table 1 : Tests to be carried out on electrical rotating machines

No.	Tests	a.c. Generators		Motors	
		Type test **(1)**	Routine test **(2)**	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection	X	X	X	X
2	Insulation resistance measurement	X	X	X	X
3	Winding resistance measurement	X	X	X	X
4	Verification of the voltage regulation system	X	X **(3)**		
5	Rated load test and temperature rise measurement	X		X	
6	Overload/overcurrent test	X	X **(4)**	X	X **(4)**
7	Verification of steady short-circuit conditions **(5)**	X			
8	Overspeed test	X	X	X **(6)**	X **(6)**
9	Dielectric strength test	X	X	X	X
10	No load test	X	X	X	X
11	Verification of degree of protection	X		X	
12	Verification of bearings	X	X	X	X

(1) Type tests on prototype machine or tests on at least the first of a batch of machines.
(2) The report on routinely tested machines is to contain the Manufacturer's serial number of the machine which has been type tested and the test result.
(3) Only functional test of voltage regulator system.
(4) Only applicable for machine of essential services rated above 100kW/kVA.
(5) Verification of steady short circuit condition applies to synchronous generators only.
(6) Not applicable for squirrel cage motors.

Table 2 : Minimum insulation resistance

Rated voltage U_n, in V	Minimum test voltage, in V	Minimum insulation resistance, in MΩ
$U_n = 250$	$2\ U_n$	1
$250 < U_n \le 1000$	500	1
$1000 < U_n \le 7200$	1000	$U_n/1000 + 1$
$7200 < U_n \le 15000$	5000	$U_n/1000 + 1$

4 Description of the test

4.1 Examination of the technical documentation, as appropriate, and visual inspection

4.1.1 Examination of the technical documentation

Technical documentation of machines rated at 100kW (kVA) and over is to be available for examination by the Surveyor.

4.1.2 Visual inspection

A visual examination of the machine is to be made to ensure, as far as is practicable, that it complies with the technical documentation.

4.2 Insulation resistance measurement

4.2.1

Immediately after the high voltage tests the insulation resistances are to be measured using a direct current insulation tester between:

a) all current carrying parts connected together and earth,

b) all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

The minimum values of test voltages and corresponding insulation resistances are given in Tab 2. The insulation resistance is to be measured close to the operating temperature, or an appropriate method of calculation is to be used.

4.3 Winding resistance measurement

4.3.1

The resistances of the machine windings are to be measured and recorded using an appropriate bridge method or voltage and current method.

4.4 Verification of the voltage regulation system

4.4.1

The alternating current generator, together with its voltage regulation system, at all loads from no load running to full load, is to be able to keep the rated voltage at the rated power factor under steady conditions within ± 2.5%. These limits may be increased to ± 3.5% for emergency sets.

4.4.2

When the generator is driven at rated speed, giving its rated voltage, and is subjected to a sudden change of symmetrical load within the limits of specified current and power factor, the voltage is not to fall below 85% nor exceed 120% of the rated voltage

4.4.3

The voltage of the generator is then to be restored to within plus or minus 3% of the rated voltage for the main generator sets in not more than 1.5 s. For emergency sets, these values may be increased to plus or minus 4% in not more than 5 s.

4.4.4

In the absence of precise information concerning the maximum values of the sudden loads, the following conditions may be assumed: 60% of the rated current with a power factor of between 0.4 lagging and zero to be suddenly switched on with the generator running at no load, and then switched off after steady - state conditions have been reached. Subject to Classification Society's approval, such voltage regulation during transient conditions may be calculated values based on the previous type test records, and need not to be tested during factory testing of a generator.

4.5 Rated load test and temperature rise measurements

4.5.1

The temperature rises are to be measured at the rated output, voltage and frequency and for the duty for which the machine is rated and marked in accordance with the testing methods specified in IEC 60034-1, or by means of a combination of other tests.

The limits of temperature rise are those specified in IEC 60034-1 adjusted as necessary for the ambient reference temperatures specified in Sec 2.

4.6 Overload/overcurrent tests

4.6.1

Overload test is to be carried out as a type test for generators as proof of overload capability of generators and the excitation system, for motors as proof of momentary excess torque as required in IEC 60034-1. The overload test can be replaced at a routine test by an overcurrent test. The overcurrent test is to be proof of the current capability of the windings, wires, connections etc. of each machine. The overcurrent test can be performed at reduced speed (motors) or at short-circuit (generators).

4.6.2

In the case of machines for special uses (e.g. for windlasses), overload values other than the above may be considered.

4.7 Verification of steady short-circuit conditions

4.7.1

It is to be verified that under steady state short-circuit conditions, the generator with its voltage regulating system is capable of maintaining, without sustaining any damage, a current of at least three times the rated current for a duration of at least 2 s or, where precise data is available, for a duration of any time delay which may be fitted in a tripping device for discrimination purposes.

In order to provide sufficient information to the party responsible for determining the discrimination settings in the distribution system where the generator is going to be used, the generator manufacturer shall provide documentation showing the transient behaviour of the short circuit current upon a sudden short-circuit occurring when excited, and running at nominal speed. The influence of the automatic voltage regulator shall be taken into account, and the setting parameters for the voltage regulator shall be noted together with the decrement curve. Such a decrement curve shall be available when the setting of the distribution system's short-circuit protection is calculated. The decrement curve need not be based on physical testing. The manufacturers simulation model for the generator and the voltage regulator may be used where this has been validated through the previous type test on the same model.

4.8 Overspeed test

4.8.1

Machines are to withstand the overspeed test as specified in IEC 60034-1. This test is not applicable for squirrel cage motors.

4.9 Dielectric strength test

4.9.1

New and completed rotating machines are to withstand a dielectric test as specified in IEC 60034-1.

4.9.2

For high voltage machines an impulse test is to be carried out on the coils according to Sec 13.

4.9.3

When it is necessary to perform an additional high voltage test, this is to be carried out after any further drying, with a test voltage of 80% of that specified in IEC 60034-1.

4.9.4

Completely rewound windings of used machines are to be tested with the full test voltage applied in the case of new machines.

4.9.5

Partially rewound windings are to be tested at 75% of the test voltage required for new machines. Prior to the test, the old part of the winding is to be carefully cleaned and dried.

4.9.6

Following cleaning and drying, overhauled machines are to be subjected to a test at a voltage equal to 1,5 times the rated voltage, with a minimum of 500 V if the rated voltage is less than 100 V, and with a minimum of 1000 V if the rated voltage is equal to or greater than 100 V.

4.9.7

A repetition of the high voltage test for groups of machines and apparatus is to be avoided if possible, but if a test on an assembled group of several pieces of new apparatus, each of which has previously passed its high voltage test, is performed, the test voltage to be applied to such assembled group is 80% of the lowest test voltage appropriate for any part of the group.

Note 1: For windings of one or more machines connected together electrically, the voltage to be considered is the maximum voltage that occurs in relation to earth.

4.10 No load test

4.10.1

Machines are to be operated at no load and rated speed whilst being supplied at rated voltage and frequency as a motor while generators are to be driven by a suitable means and excited to give rated terminal voltage.

During the running test, the vibration of the machine and operation of the bearing lubrication system, if appropriate, are to be checked.

4.11 Verification of degree of protection

4.11.1

As specified in IEC 60034-5.

4.12 Verification of bearings

4.12.1

Upon completion of the above tests, machines which have sleeve bearings are to be opened upon request for examination by the Surveyor, to establish that the shaft is correctly seated in the bearing shells.

5 Requirements for AC Generating sets

5.1 General

5.1.1

This Section provides requirements for AC Generating sets (i.e. Reciprocating Internal Combustion enginesa), b), alternatorsc) and couplings) in addition to those stated Ch 1, Sec 2; Ch 1, Sec 16; Ch 1, App 1 of Tasneef Rules for the Classification of Ships and Sec 4.

a) Reciprocating Internal Combustion engines are to comply with the requirements in Ch 1, Sec 2; Ch 1, Sec 16 and Ch 1, App 1of Tasneef Rules for the Classification of Ships.

b) The Reciprocating Internal Combustion engine speed governor and overspeed protective device are to comply with the requirements of Ch 1, Sec 2, [4.7.3] to [4.7.7].

c) Alternators are to comply with the requirements in Sec 4.

5.1.2

The requirements are applicable to AC generating sets driven by reciprocating internal combustion engines irrespective of their types (i.e. diesel engine, dual fuel engine, gasfuel engine), except for those sets consisting of a propulsion engine which also drives power take off (PTO) generator(s).

5.2 Generating sets - requirements

5.2.1

The generating set shall show torsional vibration levels which are compatible with the allowable limits for the alternator, shafts, coupling and damper.

5.2.2

The coupling selection for the generating set shall take into account the stresses and torques imposed on it by the torsional vibration of the system. Where flexible couplings are adopted, the provisions of Ch 1, Sec 7, [2.5.4] b) and

Ch 1, Sec 9, [3.6.3] are to be complied with. The torsional vibration calculations are to be submitted to the Society for approval when the engine power is 110 kW or above.

5.2.3

The rated power shall be appropriate for the actual use of the generator set.

5.2.4

The entity responsible of assembling the generating set shall install a rating plate marked with at least the following information:

(i) the generating set manufacturer's name or mark;

(ii) the set serial number;

(iii) the set date of manufacture (month/year);

(iv) the rated power (both in kW and KVA) with one of the prefixes COP, PRP (or, only for emergency Generating sets, LTP) as defined in ISO 8528-1:2018;

(v) the rated power factor;

(vi) the set rated frequency (Hz);

(vii) the set rated voltage (V Sec 4);

(viii) the set rated current (A);

(ix) the mass (kg).

SECTION 5 TRANSFORMERS

1 Constructional and operational requirements

1.1 Construction

1.1.1 Transformers, except those for motor starting, are to be double wound (two or more separate windings).

1.1.2 Transformers are normally to be of the dry, air-cooled type.

1.1.3 When a forced air cooling system is used, an alarm is to be activated in the event of its failure.

1.1.4 Liquid-cooled transformers may be used provided that:
- the liquid is non-toxic and of a type which does not readily support combustion
- the construction is such that the liquid is not spilled in inclined position
- temperature and pressure relief devices with an alarm are installed
- drip trays or other suitable arrangements for collecting the liquid from leakages are provided
- a liquid gauge indicating the normal liquid level range is fitted.

1.1.5 Transformers are to have enclosures with a degree of protection in accordance with Sec 3, Tab 2.

1.2 Terminals

1.2.1 Suitable fixed terminal connections are to be provided in an accessible position with sufficient space for convenient connection of the external cables.

1.2.2 Terminals are to be clearly identified.

1.3 Short-circuit conditions and parallel operation

1.3.1 In determining the voltage ratio and the impedance voltage of transformers, account is to be taken of the total permitted voltage drop from the main switchboard's busbars to the consumers (see Sec 3, [9.11.4]).

1.3.2 Transformers are to be constructed to withstand, without damage, the thermal and mechanical effects of a secondary terminal short-circuit for 2 s, with rated primary voltage and frequency.
For transformers of 1 MVA and over, this is to be justified with appropriate tests or documentation.

1.3.3 When transformers are so arranged that their secondary windings may be connected in parallel, their winding connections are to be compatible, their rated voltage ratios are to be equal (with tolerances allowed) and their short-circuit impedance values, expressed as a percentage, are to have a ratio within 0,9 to 1,1.
When transformers are intended for operation in parallel, the rated power of the smallest transformer in the group is to be not less than half of the rated power of the largest transformer in the group.

1.4 Electrical insulation and temperature rise

1.4.1 Insulating materials for windings and other current carrying parts are to comply with the requirements of Sec 2.

1.4.2 All windings of air-cooled transformers are to be suitably treated to resist moisture, air salt mist and oil vapours.

1.4.3 The permissible limits of temperature rise with an ambient air temperature of 45°C for (natural or forced) air-cooled transformers are given in Tab 1. The temperature rises shown for windings refer to measurement by the resistance method while those for the core refer to the thermometer method.

1.4.4 For dry-type transformers cooled with an external liquid cooling system, the permissible limits of temperature rise with a sea water temperature of 32°C are 13°C higher than those specified in Tab 1.

1.4.5 For liquid-cooled transformers, the following temperature rises measured by the resistance method apply:
- 55°C where the fluid is cooled by air

- 68°C where the fluid is cooled by water.

1.5 Insulation tests

1.5.1 Transformers are to be subjected to a high voltage test in accordance with the procedure defined in Sec 4, [4.9].

1.5.2 The test voltage is to be applied between each winding under test and the other windings not under test, core and enclosure all connected together.

Single-phase transformers for use in a polyphase group are to be tested in accordance with the requirements applicable to that group.

1.5.3 The r.m.s. value of the test voltage is to be equal to 2 U + 1000 V, with a minimum of 2500 V, where U is the rated voltage of the winding. The full voltage is to be maintained for 1 minute.

1.5.4 Partially rewound windings are to be tested at 75% of the test voltage required for new machines.

Table 1 : Temperature rise limits for transformers

No.	Part of machine	Temperature rise by class of insulation, in °C				
		A	E	B	F	H
1	Windings	55	70	75	95	120
2	Cores and other parts: a) in contact with the windings b) not in contact with the windings	a) the same values as for the windings b) in no case is the temperature to reach values such as to damage either the core itself or other adjacent parts or materials				

1.5.5 The insulation resistance of a new, clean and dry transformer, measured after the temperature rise test has been carried out (at or near operating temperature) at a voltage equal to 500 V d.c., is to be not less than 5 MΩ.

1.5.6 Transformers are to be subjected to an induced voltage insulation test by applying to the terminals of the winding under test a voltage equal to twice the rated voltage. The duration of the test is to be 60 s for any test frequency fp up to and including twice the rated frequency fn.

If the test frequency exceeds twice the rated frequency, the test time in seconds will be 120 f_n/f_p with a minimum of 15 s.

2 Testing

2.1 General

2.1.1 On new transformers intended for essential services the tests specified in [2.2] are to be carried out.

2.1.2 The manufacturer is to issue a test report giving, inter alia, information concerning the construction, type, serial number, insulation class and all other technical data relevant to the transformer, as well as the results of the tests required.

Such test reports are to be made available to the Society.

2.1.3 In the case of transformers which are completely identical in rating and in all other constructional details, it will be acceptable for the temperature rise test to be performed on only one transformer.

The results of this test and the serial number of the tested transformer are to be inserted in the test reports for the other transformers.

2.1.4 Where the test procedure is not specified, the requirements of IEC 60076 apply.

2.1.5

When required in accordance with Part A ch.2 App.3 the tests and, if appropriate, manufacture of transformers of 100 kVA and over (60 kVA when single phase) intended for essential services are to be attended by a Surveyor of the Society.

Transformers of 5 kVA up to the limit specified above are approved on a case by case basis, at the discretion of the Society, subject to the submission of adequate documentation and routine tests.

Note 1: An Alternative Certification Scheme may be agreed by the Society with the Manufacturer whereby the attendance of the Surveyor will not be required as indicated above.

2.2 Tests on transformers

2.2.1 Tests to be carried out on transformers are specified in Tab 2.

Table 2 : Tests to be carried out on transformers

No.	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)**	X	X
2	Insulation resistance measurement	X	X
3	High voltage test	X	X
4	Temperature rise measurement	X	
5	Induced voltage test	X	X
6	Voltage ratio	X	X

(1) Type test on prototype transformer or test on at least the first batch of transformers.
(2) The certificates of transformers routine tested are to contain the manufacturer's serial number of the transformer which has been type tested and the test result.
(3) A visual examination is to be made of the transformer to ensure, as far as practicable, that it complies with technical documentation.

SECTION 6 SEMICONDUCTOR CONVERTORS

1 Constructional and operational requirements

1.1 Construction

1.1.1 Semiconductor convertors are generally to comply with the requirements for switchgear assemblies (see Sec 8).

1.1.2 The monitoring and control circuits are generally to comply with the requirements of Chapter 3.

1.1.3 For liquid-cooled convertors the following provisions are to be satisfied:

- liquid is to be non-toxic and of low flammability
- drip trays or other suitable means are to be provided to contain any liquid leakages
- the resistivity of the cooling fluid in direct contact with semiconductor or other current carrying parts is to be monitored and an alarm initiated if the resistivity is outside the specified limits.

1.1.4 Where forced cooling is used, the temperature of the heated cooling medium is to be monitored.

If the temperature exceeds a preset value an alarm is to be given and the shutdown of the convertor is to be activated.

1.1.5 Where forced (air or liquid) cooling is provided, it is to be so arranged that the convertor cannot be or remain loaded unless effective cooling is maintained.

Alternatively, other effective means of protection against overtemperature may be provided.

1.1.6 Stacks of semiconductor elements, and other equipment such as fuses, or control and firing circuit boards etc., are to be so arranged that they can be removed from equipment without dismantling the complete unit.

1.1.7 Semiconductor convertors are to be rated for the required duty having regard to the peak loads, system transient and overvoltage and to be dimensioned so as to withstand the maximum short-circuit currents foreseen at the point of installation for the time necessary to trip the protection of the circuits they supply.

1.2 Protection

1.2.1 Semiconductor elements are to be protected against short-circuit by means of devices suitable for the point of installation in the network.

1.2.2 Overcurrent and overvoltage protection is to be installed to protect the convertor. When the semiconductor convertor is designed to work as an inverter supplying the network in transient periods, precautions necessary to limit the current are to be taken.

1.2.3 Semiconductor convertors are not to cause distortion in the voltage wave form of the power supply at levels exceeding the voltage wave form tolerances at the other user input terminals (see Sec 2, [2.2]).

1.2.4 An alarm is to be provided for tripping of protective devices against overvoltages and overcurrents in electric propulsion convertors and for convertors for the emergency source of power.

1.3 Parallel operation with other power sources

1.3.1 For convertors arranged to operate in parallel with other power sources, load sharing is to be such that under normal operating conditions overloading of any unit does not occur and the combination of paralleled equipment is stable.

1.4 Temperature rise

1.4.1 The permissible limit of temperature rise of the enclosure of the semiconductors is to be assessed on the basis of an ambient air temperature of 45°C or sea water temperature of 32°C for water-cooled elements, taking into account its specified maximum permissible temperature value.

1.4.2 The value of the maximum permissible temperature of the elements at the point where this can be measured (point of reference) is to be stated by the manufacturer.

1.4.3 The value of the mean rated current of the semiconductor element is to be stated by the manufacturer.

1.5 Insulation test

1.5.1 The test procedure is that specified in IEC Publication 60146.

1.5.2 The effective value of the test voltage for the insulation test is to be as shown in Tab 1.

Table 1 : Test voltages for high voltage test on static convertors

$\frac{U_m}{\sqrt{2}} = U$ in V **(1)**	Test voltage V
$U \leq 60$	600
$60 < U \leq 90$	900
$90 < U$	$2U + 1000$ (at least 2000)
(1) U_m: highest crest value to be expected between any pair of terminals.	

2 Testing

2.1 General

2.1.1

All the convertors are to be subjected to the tests stated in [2.2].

2.1.2

For convertors intended for essential services the manufacturer is to provide a test report, giving information on the construction, type, serial number and all technical data relevant to the convertor, as well as the results of the tests required; for other convertors the test report is to be made available upon request.

Note 1: An Alternative Certification Scheme may be agreed by the Society with the Manufacturer whereby the attendance of the Surveyor will not be required as indicated above.

2.1.3 In the case of convertors which are completely identical in rating and in all other constructional details, it will be acceptable for the rated current test and temperature rise measurement stipulated in [2.2] not to be repeated.

2.1.4 When required in Part A ch 2 App.3 the tests and, if appropriate, manufacture of convertors of 50 kVA and over intended for essential services are to be attended by a Surveyor of the Society.

2.2 Tests on convertors

2.2.1 Convertors are to be subjected to tests in accordance with Tab 2.

Type tests are the tests to be carried out on a prototype convertor or the first of a batch of convertors, and routine tests are the tests to be carried out on subsequent convertors of a particular type.

2.2.2 Final approval of convertors is to include complete function tests after installation on board, performed with all yacht’s systems in operation and in all characteristic load conditions.

Table 2 : Tests to be carried out on static convertors

No.	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)** including check of earth continuity	X	X
2	Light load function test to verify all basic and auxiliary functions	X	X
3	Rated current test	X	
4	Temperature rise measurement	X	
5	Insulation test (dielectric strength test and insulation resistance measurement)	X	X
6	Protection of the convertors in case of failure of forced cooling system	X	X

(1) Type test on prototype convertor or test on at least the first batch of convertors.
(2) The certificates of convertors routine tested are to contain the manufacturer's serial number of the convertor which has been type tested and the test result.
(3) A visual examination is to be made of the convertor to ensure, as far as practicable, that it complies with technical documentation.

SECTION 7 STORAGE BATTERIES, CHARGERS, UNINTERRUPTIBLE POWER SYSTEMS AND FUEL CELLS

1 Constructional requirements for batteries

1.1 General

1.1.1 The requirements of this Article apply to permanently installed storage batteries (not to portable batteries).

1.1.2

Storage batteries may be of the lead-acid or nickel-alkaline type, due consideration being given to the suitability for any specific application.

The use of batteries other than Lead-acid or alkaline batteries is allowed subject to the compliance of the battery system and its installation to the requirements given in App 2.

Storage batteries of satisfactorily proven design (e.g. silver/zinc) may be accepted provided they are suitable for board use to the satisfaction of the Society.

1.1.3 Cells are to be assembled in suitable crates or trays equipped with handles for convenient lifting.

1.2 Vented batteries

1.2.1 Vented batteries are those in which the electrolyte can be replaced and freely releases gas during periods of charge and overcharge.

1.2.2 Vented batteries are to be constructed to withstand the movement of the yacht and the atmosphere (salt mist, oil etc.) to which they may be exposed.

1.2.3 Battery cells are to be so constructed as to prevent spilling of electrolyte at any inclination of the battery up to 40° from the vertical.

1.2.4 It is to be possible to check the electrolyte level and the pH.

1.3 Valve-regulated sealed batteries

1.3.1 Valve-regulated sealed batteries are batteries whose cells are closed under normal conditions but which have an arrangement which allows the escape of gas if the internal pressure exceeds a predetermined value. The cells cannot normally receive addition to the electrolyte.

Note 1: The cells of batteries which are marketed as “sealed” or “maintenance free” are fitted with a pressure relief valve as a safety precaution to enable uncombined gas to be vented to the atmosphere; they should more properly be referred to as valve-regulated sealed batteries. In some circumstances the quantity of gas vented can be up to 25% of the equivalent vented design. The design is to take into consideration provision for proper ventilation.

1.3.2 Cell design is to minimise risks of release of gas under normal and abnormal conditions.

1.4 Tests on batteries

1.4.1 The battery autonomy is to be verified on board in accordance with the operating conditions.

2 Constructional requirements for chargers

2.1 Characteristics

2.1.1 Chargers are to be adequate for the batteries for which they are intended and provided with a voltage regulator.

2.1.2 In the absence of indications regarding its operation, the battery charger is to be such that the completely discharged battery can be recharged to 80% capacity within a period of 10 hours without exceeding the maximum permissible charging current. A charging rate other than the above (e.g. fully charged within 6 hours for batteries for starting of motors) may be required in relation to the use of the battery.

2.1.3 For floating service or for any other condition where the load is connected to the battery while it is on charge, the maximum battery voltage is not to exceed the safe value of any connected apparatus.

Note 1: Consideration is to be given to the temperature variation of the batteries.

2.1.4 The battery charger is to be designed so that the charging current is set within the maximum current allowed by the manufacturer when the battery is discharged and the floating current to keep the battery fully charged.

2.1.5 Trickle charging to neutralise internal losses is to be provided. An indication is to be provided to indicate a charging voltage being present at the charging unit.

2.1.6 Protection against reversal of the charging current is to be provided.

2.1.7 Battery chargers are to be constructed to simplify maintenance operation. Indications are to be provided to visualise the proper operation of the charger and for troubleshooting.

2.2 Tests on chargers

2.2.1 Battery chargers are to be subjected to tests in accordance with Tab 1.

Type tests are the tests to be carried out on a prototype charger or the first of a batch of chargers, and routine tests are the tests to be carried out on subsequent chargers of a particular type.

2.2.2

When requested in Part A ch.2 App.3 the tests of battery chargers of 50 kVA and over intended for essential services are to be attended by a Surveyor of the Society.

Note 1: An Alternative Certification Scheme may be agreed by the Society with the Manufacturer whereby the attendance of the Surveyor will not be required as indicated above.

3 Uninterruptible power system (UPS) units as alternative and/or transitional power

3.1 Application

3.1.1

These requirements for UPS units apply when providing an alternative power supply or transitional power supply to services as defined in Sec 3, [2.3] and [3.7] and when providing an alternative power supply to primary essential services as defined in Sec 1, [3.3.1].

A UPS unit complying with these requirements may provide an alternative power supply as an accumulator battery in terms of being an independent power supply for services defined in Sec 3, [3.7.3] d) and primary essential services as defined in Sec 1, [3.3.1].

3.2 Definitions

3.2.1

Uninterruptible Power System (UPS) - combination of convertors, switches and energy storage means, for example batteries, constituting a power system for maintaining continuity of load power in case of input power failure

Off-line UPS unit - a UPS unit where under normal operation the output load is powered from the bypass line (raw mains) and only transferred to the inverter if the bypass supply fails or goes outside preset limits. This transition will invariably result in a brief (typically 2 to 10 ms) break in the load supply.

Line interactive UPS unit - an off-line UPS unit where the bypass line switches to stored energy power when the input power goes outside the preset voltage and frequency limits.

On-line UPS unit - a UPS unit where, under normal operation, the output load is powered from the inverter and will therefore continue to operate without a break in the event of the supply input failing or going outside preset limits.

3.3 Design and construction

3.3.1

UPS units are to be constructed in accordance with IEC 62040-1, IEC 62040-2, IEC 62040-3, IEC 62040-4 and/or IEC 62040-5-3, as applicable, or an acceptable and relevant national or international standard.

3.3.2

The operation of the UPS is not to depend upon external services.

3.3.3

The type of UPS unit employed, whether off-line, line interactive or on-line, is to be appropriate to the power supply requirements of the connected load equipment.

3.3.4

An external bypass is to be provided.

3.3.5

The UPS unit is to be monitored and audible and visual alarm is to be given in a normally attended location for:

- power supply failure (voltage and frequency) to the connected load,
- earth fault,
- operation of a battery protective device,
- when the battery is being discharged, and
- when the bypass is in operation for on-line UPS units.

3.4 Location

3.4.1

The UPS unit providing an alternative power supply or transitional power supply to services as defined in Sec 3, [2.3] and [3.7] is to be suitably located for use in an emergency.

3.4.2

UPS units using valve regulated sealed batteries may be located in compartments with normal electrical equipment, provided the ventilation arrangements are in accordance with the requirements of IEC 62040-1, IEC 62040-2, IEC 62040-3, IEC 62040-4 and/or IEC 62040-5-3, as applicable, or an acceptable and relevant national or international standard.

3.5 Performance

3.5.1

The output power is to be maintained for the duration required for the connected emergency services.

3.5.2

No additional circuits are to be connected to the UPS unit without verification that the latter has adequate capacity. The UPS battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in the regulations.

3.5.3

On restoration of the input power, the rating of the charge unit is to be sufficient to recharge the batteries while maintaining the output supply to the load equipment.

3.6 Testing and survey

3.6.1

When required in Pt A, Ch 2, App 3 UPS units of 50 kVA and over are to be surveyed by the Society during manufacturing and testing.

3.6.2

Appropriate testing is to be carried out to demonstrate that the UPS unit is suitable for its intended environment. This is expected to include, as a minimum, the following tests:

- Functionality, including operation of alarms;

- Temperature rise;
- Ventilation rate;
- Battery capacity.

3.6.3
Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by means of a practical test.

Table 1 : Tests to be carried out on battery chargers

No.	Tests	Type test **(1)**	Routine test **(2)**
1	Examination of the technical documentation, as appropriate, and visual inspection **(3)** including check of earth continuity	X	X
2	Functional tests (current and voltage regulation, quick, slow, floating charge, alarms)	X	X
3	Temperature rise measurement	X	
4	Insulation test (dielectric strength test and insulation resistance measurement)	X	X

(1) Type test on prototype battery charger or test on at least the first batch of battery chargers.
(2) The certificates of battery chargers routine tested are to contain the manufacturer's serial number of the battery charger which has been type tested and the test result.
(3) A visual examination is to be made of the battery charger to ensure, as far as practicable, that it complies with technical documentation.

4 Fuel cells

4.1 General

4.1.1
The requirements of this Article apply to fuel cells installed on board.

4.1.2
The use of fuel cells is allowed subject to the compliance of the fuel cell power installation to the requirements given in App 5.

SECTION 8 SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

1 Constructional requirements for main and emergency switchboards

1.1 Construction

1.1.1
Construction is to be in accordance with IEC Publication 60092-302-2.

1.1.2
Switchboard manufactured and tested to standards other than those specified in [1.1.1] will be accepted provided they are in accordance with an acceptable international or national standard of an equivalent or higher safety level.

1.1.3 Where the framework, panels and doors of the enclosure are of steel, suitable measures are to be taken to prevent overheating due to the possible circulation of eddy currents.

1.1.4 Insulating material for panels and other elements of the switchboard is at least to be moisture-resistant and flame-retardant.

1.1.5 Switchboards are to be of dead front type, with enclosure protection according to Sec 3, Tab 2.

1.1.6 Switchboards are to be provided with insulated handrails or handles fitted in an appropriate position at the front of the switchboard. Where access to the rear is necessary for operational or maintenance purposes, an insulated handrail or insulated handles are to be fitted.

1.1.7 Where the aggregate capacity of generators connected to the main busbars exceeds 100 kVA, a separate cubicle for each generator is to be arranged with flame-retardant partitions between the different cubicles. Similar partitions are to be provided between the generator cubicles and outgoing circuits.

1.1.8 Instruments, handles or push-buttons for switchgear operation are to be placed on the front of the switchboard. All other parts which require operation are to be accessible and so placed that the risk of accidental touching of live parts, or accidental making of short-circuits and earthings, is reduced as far as practicable.

1.1.9 Where it is necessary to make provision for the opening of the doors of the switchboard, this is to be in accordance with one of the following requirements:

a) opening is to necessitate the use of a key or tool (e.g. when it is necessary to replace a lamp or a fuse-link)
b) all live parts which can be accidentally touched after the door has been opened are to be disconnected before the door can be opened
c) the switchboard is to include an internal barrier or shutter with a degree of protection not less than IP2X shielding all live parts such that they cannot accidentally be touched when the door is open. It is not to be possible to remove this barrier or shutter except by the use of a key or tool.

1.1.10 All parts of the switchboard are to be readily accessible for maintenance, repair or replacement. In particular, fuses are to be able to be safely inserted and withdrawn from their fuse-bases.

1.1.11 Hinged doors which are to be opened for operation of equipment on the door or inside are to be provided with fixing devices for keeping them in open position.

1.1.12 Means of isolation of the circuit-breakers of generators and other important parts of the installation are to be provided so as to permit safe maintenance while the main busbars are alive.

1.1.13 Where components with voltage exceeding the safety voltage are mounted on hinged doors, the latter are to be electrically connected to the switchboard by means of a separate, flexible protective conductor.

1.1.14 All measuring instruments and all monitoring and control devices are to be clearly identified with indelible labels of durable, flame-retardant material.

1.1.15 The rating of each circuit, together with the rating of the fuse or the appropriate setting of the overload protective device (circuit-breaker, thermal relay etc.) for each circuit is to be permanently indicated at the location of the fuse or protective device.

1.2 Busbars and bare conductors

1.2.1 Busbars are to be of copper or of copper-surrounded aluminium alloy if suitable for use in the marine environment and if precautions are taken to avoid galvanic corrosion.

1.2.2 All connections are to be so made as to inhibit corrosion.

1.2.3 Busbars are to be dimensioned in accordance with IEC Publication 60092-302.

The mean temperature rise of busbars is not to exceed 45°C under rated current condition with an ambient air temperature of 45°C (see Sec 2, [1.2.5]) and is not to have any harmful effect on adjacent components. Higher values of temperature rise may be accepted to the satisfaction of the Society.

1.2.4 The cross-section of neutral connection on an a.c. three-phase, four-wire system is to be at least 50% of the cross-section for the corresponding phases.

1.2.5 Bare main busbars, excluding the conductors between the main busbars and the supply side of outgoing units, are to have the minimum clearances and creepage distances given in Tab 1.

The values shown apply to clearances and creepage distances between live parts as well as between live parts and exposed conductive parts.

Table 1 : Clearance and creepage distances

Rated insulation voltage a.c. r.m.s. or d.c. V	Minimum clearance mm	Minimum creepage distance mm
≤ 250	15	20
> 250 to ≤ 690	20	25
> 690	25	35

Note 1: Clearance is the distance between two conductive parts along a string stretched the shortest way between such parts. Creepage distance is the shortest distance along the surface of an insulating material between two conductive parts.

1.2.6 Reduced values as specified in IEC Publication 60092-302 may be accepted for type tested and partially type tested assemblies.

The reference values for the evaluation of the minimum clearances and creepage distances for these assemblies are based on the following:

- pollution degree 3 (conductive pollution occurs, or dry non-conductive pollution occurs which becomes conductive due to condensation which is expected)
- overvoltage category III (distribution circuit level)
- inhomogenous field conditions (case A)
- rated operational voltage 1000 V a.c., 1500 V d.c.
- group of insulating material IIIa.

Special consideration is to be given to equipment located in spaces where a pollution degree higher than 3 is applicable, e.g. in diesel engine rooms.

1.2.7 Busbars and other bare conductors with their supports are to be mechanically dimensioned and fixed such that they can withstand the stresses caused by short-circuits.

1.2.8 Busbars and bare conductors are to be protected, where necessary, against falling objects (e.g. tools, fuses or other objects).

1.3 Internal wiring

1.3.1 Insulated conductors for internal wiring of auxiliary circuits of switchboards are to be constructed in accordance with Sec 9, [1.1.5].

1.3.2 All insulated conductors provided for in [1.3.1] are to be of flexible construction and of the stranded type.

1.3.3 Connections from busbars to protective devices are to be as short as possible. They are to be laid and secured in such a way to minimise the risk of a short-circuit.

1.3.4 All conductors are to be secured to prevent vibration and are to be kept away from sharp edges.

1.3.5 Connections leading to indicating and control instruments or apparatus mounted in doors are to be installed such that they cannot be mechanically damaged due to movement of the doors.

1.3.6 Non-metallic trays for internal wiring of switchboards are to be of flame-retardant material.

1.3.7 Control circuits are to be installed and protected such that they cannot be damaged by arcs from the protective devices.

1.3.8 Where foreseen, fixed terminal connectors for connection of the external cables are to be arranged in readily accessible positions.

1.4 Switchgear and controlgear, protective devices

1.4.1
Switchgear and controlgear are to comply with IEC 60947 series adjusted as necessary for the ambient air reference temperature specified in Sec 2, Tab 1 and to be type tested or type approved when required in accordance with Sec 15.

1.4.2 The characteristics of switchgear, controlgear and protective devices for the various consumers are to be in compliance with Sec 3, [7].

1.4.3
For high voltage switchgear and controlgear see Sec 13, [7].

1.4.4
For materials and construction, see Sec 2, [4] and Sec 2, [5].

1.4.5
Power-driven circuit-breakers are to be equipped with an additional separate drive operated by hand.

1.4.6
Power circuit-breakers with a making capacity exceeding 10 kA are to be equipped with a drive which performs the make operation independently of the actuating force and speed.

1.4.7
Where the conditions for closing the circuit-breaker are not satisfied (e.g. if the undervoltage trip is not energised), the closing mechanism is not to cause the closing of the contacts.

1.4.8
All circuit-breakers rated more than 16 A are to be of the trip-free type, i.e. the breaking action initiated by overcurrent or undervoltage releases is to be fulfilled independently of the position of the manual handle or other closing devices.

1.4.9
Short-circuit releases are generally to be independent of energy supplied from circuits other than that to be protected. Tripping due to short-circuit is to be reliable even in the event of a total loss of voltage in the protected circuit.

1.4.10
Short-circuit releases for generators are to be equipped with reclosing inhibitors and are to be delayed for selective tripping.

1.4.11
Overload releases or relays are to operate reliably at any voltage variation of the supply voltage in the protected circuit.

1.4.12
Undervoltage relays or releases are to cause the circuit-breaker to open if the voltage drops to 70%-35% of the rated voltage.

1.4.13
Shunt releases are to ensure the disconnection of the circuit-breaker even when the supply voltage of the release drops to 85% of the rated supply voltage.

1.4.14
The reverse power protection device is to respond to the active power regardless of the power factor, and is to operate only in the event of reverse power.

1.4.15
Single-phase failure devices in three-phase circuits are to operate without a time lag.

1.4.16
Insulation monitoring devices are to continuously monitor the insulation resistance to earth and trigger an alarm should the insulation resistance fall below a predetermined value.

The measuring current of such devices is not to exceed 30 mA in the event of a total short to earth.

1.5 Fuses

1.5.1
Low voltage fuses are to comply with IEC Publication 60269 series and are to be type tested or type approved when required in accordance with Sec 15, [2.1.1].

1.5.2
For high voltage fuses see Sec 13, [7].

1.6 Auxiliary circuits

1.6.1 Auxiliary circuits are to be designed in such a manner that, as far as practicable, faults in such circuits do not impair the safety of the system. In particular, control circuits are to be designed so as to limit the dangers resulting from a fault between the control circuit and earth (e.g. inadvertent operation or malfunction of a component in the installation), also taking account of the earthing system of their supply.

1.6.2 Auxiliary circuits of essential systems are to be independent of other auxiliary circuits.

1.6.3 Common auxiliary circuits for groups of consumers are permitted only when the failure of one consumer jeopardises the operation of the entire system to which it belongs.

1.6.4 Auxiliary circuits are to be branched off from the main circuit in which the relevant switchgear is used.

1.6.5 The supply of auxiliary circuits by specifically arranged control distribution systems will be specially considered by the Society.

1.6.6 Means are to be provided for isolating the auxiliary circuits as well when the main circuit is isolated (e.g. for maintenance purposes).

1.6.7 For the protection of auxiliary circuits see Sec 3, [7.13].

1.7 Instruments

1.7.1 The upper limit of the scale of every voltmeter is to be not less than 120% of the rated voltage of the circuit in which it is installed.

1.7.2 The upper limit of the scale of every ammeter is to be not less than 130% of the normal rating of the circuit in which it is installed.

1.7.3 The upper limit of the scale of every wattmeter is to be not less than 120% of the rated voltage of the circuit in which it is installed.

1.7.4 Wattmeters for use with a.c. generators which may be operated in parallel are to be capable of indicating 15% reverse power.

1.7.5 For wattmeters using one current circuit only, the measurement of the current of all generators is to be made in the same phase.

1.7.6 The rated value of the measure read, at full load, is to be clearly indicated on the scales of instruments.

1.7.7 Frequency meters are to have a scale at least ± 5% of the nominal frequency.

1.7.8 The secondary windings of instrument transformers are to be earthed.

1.7.9 Each a.c. generator not operated in parallel is to be provided with:

- 1 voltmeter
- 1 frequency meter
- 1 ammeter in each phase or 1 ammeter with a selector switch to enable the current in each phase to be read
- 1 three-phase wattmeter in the case of generators rated more than 50 kVA.

1.7.10 Each a.c. generator operated in parallel is to be provided with:

- 1 three-phase wattmeter
- 1 ammeter in each phase or 1 ammeter with a selector switch to enable the current in each phase to be read.

1.7.11 For paralleling purposes the following are to be provided:

- 2 voltmeters
- 2 frequency meters
- 1 synchroscope and synchronising indicating lamps or equivalent means.

A switch is to be provided to enable one voltmeter and one frequency meter to be connected to each generator before the latter is connected to the busbars.

The other voltmeter and frequency meter are to be permanently connected to the busbars.

1.7.12 Each secondary distribution system is to be provided with one voltmeter.

1.7.13 Switchboards are to be fitted with means for monitoring the insulation level of insulated distribution systems as stipulated in Sec 3, [3.2.1].

1.7.14 The main switchboard is to be fitted with a voltmeter or signal lamp indicating that the cable between the shore-connection box and the main switchboard is energised (see Sec 3, [3.8.7]).

1.7.15 For each d.c. power source (e.g. convertors, rectifiers and batteries), one voltmeter and one ammeter are to be provided, except for d.c. power sources for starting devices (e.g. starting motor for emergency generator).

2 Constructional requirements for distribution boards

2.1 Construction

2.1.1

Distribution boards are to be constructed, insofar as applicable, as specified for main and emergency switchboards.

2.1.2 All parts which require operation in normal use are to be placed on the front.

2.1.3 Distribution switchboards which are provided with two or more supply circuits arranged for automatic standby connection are to be provided with positive indication of which of the circuits is feeding the switchboard.

3 Testing

3.1 General

3.1.1

The following switchgear and control gear assemblies are to be subjected to the tests specified from [3.2] to [3.4] and surveyed by the society during testing:

a) main switchboard;

b) emergency switchboard;

c) low voltage distribution boards, starters and motor control centers having busbars rated current of 100A and above;

d) high voltage assemblies;

3.1.2 The manufacturer is to issue the relative test reports providing information concerning the construction, serial number and technical data relevant to the switchboard, as well as the results of the tests required.

3.1.3 The tests are to be carried out prior to installation on board.

3.1.4
The test procedures are as specified in IEC Publication 60092-302-2.

3.2 Inspection of equipment, check of wiring and electrical operation test

3.2.1 It is to be verified that the switchboard:

- complies with the approved drawings
- maintains the prescribed degree of protection
- is constructed in accordance with the relevant constructional requirements, in particular as regards creepage and clearance distances.

3.2.2 The connections, especially screwed or bolted connections, are to be checked for adequate contact, possibly by random tests.

3.2.3 Depending on the complexity of the switchboard it may be necessary to carry out an electrical functioning test. The test procedure and the number of tests depend on whether or not the switchboard includes complicated interlocks, sequence control facilities, etc. In some cases it may be necessary to conduct or repeat this test following installation on board.

3.3 High voltage test

3.3.1 The test is to be performed with alternating voltage at a frequency between 45 and 65 Hz of approximately sinusoidal form.

3.3.2 The test voltage is to be applied:

- between all live parts connected together and earth
- between each polarity and all the other polarities connected to earth for the test.

During the high voltage test, measuring instruments, ancillary apparatus and electronic devices may be disconnected and tested separately in accordance with the appropriate requirements.

3.3.3 The test voltage at the moment of application is not to exceed half of the prescribed value. It is then to be increased steadily within a few seconds to its full value. The prescribed test voltage is to be maintained for 5 seconds (1 minute for high voltage assemblies) 1 minute. The overcurrent relay shall not trip when the output current is less than 100mA. The high-voltage transformer used for the test shall be so designed that, when the output terminals are short-circuited after the output voltage has been adjusted to the appropriate test voltage, the output current shall be at least 200 mA.

3.3.4 The value of the test voltage for main and auxiliary circuits is given in Tab 2 and Tab 3.

Table 2 : Test voltages for main circuits (based on IEC 61439-1)

Rated insulation voltage U_i V	Test voltage c.a (r.m.s.) V
$U_i \leq 60$	1000
$60 < U_i \leq 300$	1500
$300 < U_i \leq 660$	1890
$660 < U_i \leq 800$	2000
$800 < U_i \leq 1000$	2000

Table 3 : Test voltage for auxiliary circuits

Rated insulation voltage U_i V	Test voltage c.a (r.m.s.) V
$U_i \leq 12$	250
$12 < U_i \leq 60$	500
$U_i > 60$	See Tab.2

3.4 Measurement of insulation resistance

3.4.1 Immediately after the high voltage test, the insulation resistance is to be measured using a device with a direct current voltage of at least 500 V.

3.4.2 The insulation resistance between all current carrying parts and earth (and between each polarity and the other polarities) is to be at least equal to 1 MΩ.

SECTION 9 CABLES

1 Constructional requirements

1.1 Construction

1.1.1

Cables manufactured in accordance with the relevant recommendations of IEC 60092-350, 60092-360, 60092-352, 60092-353, 60092-354, 60092-370 and 60092-376 are acceptable to the Society provided that they are tested as specified in this Chapter.

1.1.2 Mineral-insulated cables are to be constructed according to IEC Publication 60702.

1.1.3 Optical fibre cables are to be constructed in accordance with IEC Publication 60794.

1.1.4 Flexible cables constructed according to national standards will be specially considered by the Society.

1.1.5

Cables manufactured and tested to standards other than those specified in [1.1.1] will be accepted provided they are in accordance with an acceptable and relevant international or national standard of an equivalent or higher safety level.

1.1.6 Insulated wiring for auxiliary circuits of switchboards may be constituted by cables with a single conductor of the stranded type for all sections, PVC- or rubber-insulated in accordance with the Publications cited in [1.1.1] and without further protection.

The insulated wiring is to be at least of the flame-retardant type according to IEC Publication 60332-1. Equivalent types of flame-retardant switchboard wires will be specially considered by the Society.

1.2 Conductors

1.2.1 Conductors are to be of annealed electrolytic copper with a resistivity not exceeding 17,241 Ω mm^2/km at 20°C according to IEC 60228.

1.2.2 Individual conductor wires of rubber-insulated cables are to be tinned or coated with a suitable alloy.

1.2.3 All conductors are to be stranded, except for cables of nominal cross-sectional area 2,5 mm^2 and less (provided that adequate flexibility of the finished cable is assured).

1.2.4 For the minimum nominal cross-sectional areas permitted, see Sec 3, [9.10].

1.3 Insulating materials

1.3.1 The materials used for insulation are to comply with IEC Publication 60092-360 and to have the thicknesses specified for each type of cable in the relevant standard. The maximum permissible rated temperature is specified for the various materials.

1.3.2 Materials and thicknesses other than those in [1.3.1] will be specially considered by the Society.

1.4 Inner covering, fillers and binders

1.4.1 The cores of a multicore cable are to be laid up. The spaces between the cores are to be filled so as to obtain an assembly having an essentially circular cross-section. The filling may be omitted in multicore cables having a conductor cross-sectional area not exceeding 4 mm^2.

When a non-metallic sheath is applied directly over the inner covering or the fillers, it may substitute partially for the inner covering or fillers.

1.4.2 The materials used, the binders and the thicknesses of the inner coverings are generally to be in accordance with IEC Publications of the series 60092-3, in relation to the type of cable.

1.5 Protective coverings (armour and sheath)

1.5.1 Metallic armour, if not otherwise protected against corrosion, is to be protected by means of a coating of protective paint (see Sec 3, [9.3]).

1.5.2 The paint is to be non-flammable and of adequate viscosity. When dry, it is not to flake off.

1.5.3 The materials and construction used for (metal) armour are to be in accordance with IEC Publication 60092-350 and their dimensions are to be those specified for each type of cable in the relevant standard.

1.5.4 The materials used for sheaths are to be in accordance with IEC Publication 60092-360 and are to have the thicknesses specified for each type of cable in the relevant standard.

The quality of the materials is to be adequate to the service temperature of the cable.

1.5.5 Materials other than those in [1.5.3] and [1.5.4] will be specially considered by the Society.

1.6 Identification

1.6.1 Each cable is to have clear means of identification so that the manufacturer can be determined.

1.6.2 Fire non propagating cables are to be clearly labelled with indication of the standard according to which this characteristic has been verified and, if applicable, of the category to which they correspond.

1.6.3

Fire-resisting cables are to be clearly labelled with the indication of the standard according to which this characteristic has been verified.

2 Testing

2.1 Type tests

2.1.1 Type tests are to be in accordance with the relevant IEC 60092-3, Series Publications and IEC 60332-1, IEC 60332-3 Category A, and IEC 60331 where applicable.

2.2 Routine tests

2.2.1 Every length of finished cable is to be subjected to the tests specified in [2.2.2].

2.2.2 The following routine tests are to be carried out:

a) visual inspection

b) check of conductor cross-sectional area by measuring electrical resistance

c) high voltage test

d) insulation resistance measurement

e) dimensional checks (as necessary).

2.2.3 The manufacturer is to issue a statement providing information on the type and characteristics of the cable, as well as the results of the tests required and the Type Approval Certificates.

2.2.4 The test procedure is as specified in IEC Publication 60092-350.

2.2.5

When required in Pt A, Ch 2, App 3 power cables for electrical propulsion systems, other than internal wiring in switchboards, are to be type approved and tested for acceptance in the presence of the Surveyor. Acceptance tests are to include at least:

a) a high voltage test

b) insulation resistance measurement.

2.2.6 Where an alternative scheme, e.g. a certified quality assurance system, is recognised by the Society, attendance of the Surveyor may not be required.

SECTION 10 MISCELLANEOUS EQUIPMENT

1 Lighting fittings

1.1 Applicable requirements

1.1.1 Lighting fittings are to comply with IEC Publications 60598 and 60092-306.

Lighting fittings complying with other standards will be specially considered by the Society.

1.2 Construction

1.2.1 The temperature of terminals for connection of supplying cables is not to exceed the maximum conductor temperature permitted for the cable (see Sec 3, [9.9]).

Where necessary, luminaires are to be fitted with terminal boxes which are thermally insulated from the light source.

1.2.2 Wires used for internal connections are to be of a temperature class which corresponds to the maximum temperature within the luminaire.

1.2.3 The temperature rise of parts of luminaires which are in contact with the support is not to exceed 50°C. The rise is not to exceed 40°C for parts in contact with flammable materials.

1.2.4 The temperature rise of surface parts which can easily be touched in service is not to exceed 15°C.

1.2.5 High-power lights with higher surface temperatures than those in [1.2.2] and [1.2.3] are to be adequately protected against accidental contact.

2 Accessories

2.1 Applicable requirements

2.1.1 Accessories are to be constructed in accordance with the relevant IEC Publications, and in particular with Publication 60092-306.

2.2 Construction

2.2.1 Enclosures of accessories are to be of metal having characteristics suitable for the intended use on board, or of flame-retardant insulating material.

2.2.2 Terminals are to be suitable for the connection of stranded conductors, except in the case of rigid conductors for mineral-insulated cables.

3 Plug-and-socket connections

3.1 Applicable requirements

3.1.1

Plug-and-socket connections are to comply with IEC Publication 60092-306 and with the following additional standards in relation to their use:

- in accommodation spaces, day rooms and service rooms (up to 16 A, 250 V a.c.): IEC Publication 60083 or 60320, as applicable
- for power circuits (up to 250 A, 690 V a.c.): IEC Publication 60309
- for electronic switchgear: IEC Publications, e.g. 60130 and 60603
- for refrigerated containers: ISO 1496-2
- for high voltage shore connections: IEC Publications 62613-1 (see Pt F, Ch 13, Sec 15).

4 Heating and cooking appliances

4.1 Applicable requirements

4.1.1 Heating and cooking appliances are to comply with the relevant IEC Publications (e.g. those of series 60335), with particular attention to IEC 60092-307.

4.2 General

4.2.1 Heating elements are to be enclosed and protected with metal or refractory material.

4.2.2 The terminals of the power supply cable are not to be subjected to a higher temperature than that permitted for the conductor of the connection cable.

4.2.3 The temperature of parts which are to be handled in service (switch knobs, operating handles and the like) is not to exceed the following values:

- 55°C for metal parts
- 65°C for vitreous or moulded material.

4.3 Space heaters

4.3.1 The casing or enclosure of heaters is to be so designed that clothing or other flammable material cannot be placed on them.

4.3.2 The temperature of the external surface of space heaters is not to exceed 60°C.

4.3.3 Space heaters are to be provided with a temperature limiting device without automatic reconnection which automatically trips all poles or phases not connected to earth when the temperature exceeds the maximum permissible value.

4.4 Cooking appliances

4.4.1 Live parts of cooking appliances are to be protected such that any foods or liquids which boil over or spill do not cause short-circuits or loss of insulation.

4.5 Fuel oil and lube oil heaters

4.5.1 In continuous-flow fuel oil and lube oil heaters, the maximum temperature of the heating elements is to be below the boiling point of the oil.

4.5.2 Each oil heater is to be provided with a thermostat maintaining the oil temperature at the correct level.

4.5.3 In addition to the thermostat in [4.5.2], each oil heater is to be provided with a temperature limiting device without automatic reconnection, and with the sensing device installed as close as possible to the heating elements and permanently submerged in the liquid.

4.6 Water heaters

4.6.1 Water heaters are to be provided with a thermostat and safety temperature limiter.

5 Cable trays/protective casings made of plastics materials

5.1 General requirement

5.1.1

Cable trays/protective casings (see Note 1) made of plastic (see Note 2) materials are to be type tested or type approved (See Note 3).

Note 1: "Protective casing" means a closed cover in the form of a pipe or other closed ducts of non-circular shape.

Note 2: "Plastics" means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and fibre reinforced plastics - FRP.

Note 3: “Cable trays/protective casings made of plastic materials” are to be type tested or type approved in accordance with the latest published version of IACS REC 73.

5.2 Installation Requirements

5.2.1

Cable trays/protective casings made of plastics materials are to be supplemented by metallic fixing and straps such that in the event of a fire they, and the cables affixed, are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route.

Note 1: When plastic cable trays/protective casings are used on open deck, they are additionally to be protected against UV light.

5.2.2

The load on the cable trays/protective casings is to be within the Safe Working Load (SWL). The support spacing is to be not greater than the Manufacturer's recommendation or in excess of the spacing at the SWL test. In general it is not to exceed 2 metres.

The selection and spacing of cable tray/protective casing supports are to take into account:

- dimensions of cable trays/protective casings;
- mechanical and physical properties of their material;
- mass of cable trays/protective casings;
- loads due to weight of cables, external forces, thrust forces and vibrations;
- maximum accelerations to which the system may be subjected;
- combination of loads.

5.2.3

The sum of the cables' total cross-sectional area, based on the cables' external diameter, is not to exceed 40% of the protective casing's internal cross-sectional area. This does not apply to a single cable in a protective casing.

SECTION 11 LOCATION

1 General

1.1 Location

1.1.1 The degree of protection of the enclosures and the environmental categories of the equipment are to be appropriate to the spaces or areas in which they are located; see Sec 3, Tab 2 and Sec 2, [5.2.2].

1.2 Areas with a risk of explosion

1.2.1 Except where the installation of equipment for explosive gas atmosphere is provided for by the Rules, electrical equipment is not to be installed where flammable gases or vapours are liable to accumulate; see Sec 3, [10].

2 Main electrical system

2.1 Location in relation to the emergency system

2.1.1 The arrangement of the emergency electrical system is to be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated converting equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render inoperative the main electric lighting system and the other primary essential services.

2.2 Main switchboard

2.2.1 The main switchboard shall be so placed relative to one main generating station that, as far as is practicable, the integrity of the normal electrical supply may be affected only by a fire or other casualty in one space.

2.2.2 An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the space, is not to be considered as separating switchboards from generators.

2.2.3 The main generating station is to be situated within the machinery space, i.e. within the extreme main transverse watertight bulkheads.

2.2.4 Any bulkhead between the extreme main transverse watertight bulkheads is not regarded as separating the equipment in the main generating station provided that there is access between the spaces.

2.2.5 The main switchboard is to be located as close as practicable to the main generating station, within the same machinery space and the same vertical and horizontal A60 fire boundaries.

2.2.6
Where essential services for steering and propulsion are supplied from distribution boards, these and any transformers, convertors and similar appliances constituting an essential part of the electrical supply system are also to satisfy the above provisions.

2.2.7 A non-required subdivision bulkhead, with sufficient access, located between the switchboard and generators, or between two or more generators, is not to be considered as separating the equipment.

3 Emergency electrical system

3.1 Spaces for the emergency source

3.1.1 The emergency source of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard shall be located above the uppermost continuous deck and shall be readily accessible from the open deck.

They shall not be located forward of the collision bulkhead.

3.1.2 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, and the main switchboard.

Where this is not practicable, the contiguous boundaries are to be Class A60.

3.2 Location in relation to the main electrical system

3.2.1 The location 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 shall 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.

3.2.2 The arrangement of the main electrical system is to be such that a fire or other casualty in spaces containing the main source of electrical power, associated converting equipment, if any, the main switchboard and the main lighting switchboard will not render inoperative the emergency electric lighting system and the other emergency services other than those located within the spaces where the fire or casualty has occurred.

3.3 Emergency switchboard

3.3.1 The emergency switchboard shall be installed as near as is practicable to the emergency source of electrical power.

3.3.2 Where the emergency source of electrical power is a generator, the emergency switchboard shall be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

3.4 Emergency battery

3.4.1 No accumulator battery fitted in accordance with the provisions of Sec 3, [2.3] shall be installed in the same space as the emergency switchboard.

3.4.2

Accumulator batteries fitted in accordance with the provisions of Sec 3, [2.3] may be accepted in the same space as the emergency switchboard, provided that they are not vented type batteries connected to a charging device of power greater than 2 kW.

4 Distribution boards

4.1 Distribution board for navigation lights

4.1.1 The distribution board for navigation lights is to be placed in an accessible position on the bridge.

5 Cable runs

5.1 General

5.1.1 Cable runs are to be selected so as to be as far as practicable accessible, with the exception of single cables, situated behind walls or ceilings constructed of incombustible materials, supplying lighting fittings and socket-outlets in accommodation spaces, or cables enclosed in pipes or conduits for installation purposes.

5.1.2 Cable runs are to be selected so as to avoid action from condensed moisture and from dripping of liquids.

5.1.3 Connection and draw boxes are to be accessible.

5.1.4 Cables are generally not to be installed across expansion joints.

Where this is unavoidable, however, a loop of cable of length proportional to the expansion of the joint is to be provided (see Sec 12, [7.2.2]).

5.2 Location of cables in relation to the risk of fire and overheating

5.2.1 Cables and wiring serving essential or emergency power, lighting, internal communications or signals are, so far as is practicable, to be routed clear of galleys, laundries, machinery spaces of Category A and their casings and other high fire risk areas, except for supplying equipment in those spaces.

5.2.2 When it is essential that a circuit functions for some time during a fire and it is unavoidable to carry the cable for such a circuit through a high fire risk area (e.g. cables connecting fire pumps to the emergency switchboard), the cable is to be of a fire-resistant type or adequately protected against direct exposure to fire.

5.2.3
Main cable runs (see Note 1) and cables for the supply and control of essential services are, as far as is practicable, to be kept away from machinery parts having an increased fire risk (see Note 2) unless:

- the cables have to be connected to the subject equipment,
- the cables are protected by a steel bulkhead or deck, or
- the cables in that area are of the fire-resisting type.

Note 1: Main cable runs are for example:

- cable runs from generators and propulsion motors to main and emergency switchboards
- cable runs directly above or below main and emergency switchboards, centralised motor starter panels, distribution boards and centralised control panels for propulsion and essential auxiliaries.

Note 2: Machinery, machinery parts or equipment handling combustibles are considered to present an increased fire risk.

5.2.4 Cables and wiring serving essential or emergency power, lighting, internal communications or signals are to be arranged, as far as practicable, in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

5.2.5 Cables are to be arranged as remote as possible from sources of heat such as hot pipes, resistors, etc. Where installation of cables near heat sources cannot be avoided, and where there is consequently a risk of damage to the cables by heat, suitable shields are to be installed, or other precautions to avoid overheating are to be taken, for example use of ventilation, heat insulation materials or special heat-resisting cables.

5.3 Location of cables in relation to electromagnetic interference

5.3.1 For the installation of cables in the vicinity of radio equipment or of cables belonging to electronic control and monitoring systems, steps are to be taken in order to limit the effects of unwanted electromagnetic interference (see Ch 3, Sec 5).

5.4 Services with a duplicate feeder

5.4.1 In the case of essential services requiring a duplicate supply (e.g. steering gear circuits), the supply and associated control cables are to follow different routes which are to be as far apart as practicable, separated both vertically and horizontally.

5.5 Emergency circuits

5.5.1 Cables supplying emergency circuits are not to run through spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard, except for cables supplying emergency equipment located within such spaces (see [3.2.2]).

6 Storage batteries

6.1 General

6.1.1 Batteries are to be located where they are not exposed to excessive heat, extreme cold, spray, steam or other conditions which would impair performance or accelerate deterioration. They are to be installed in such a way that no damage may be caused to surrounding appliances by the vapours generated.

6.1.2 Storage batteries are to be suitably housed, and compartments (rooms, lockers or boxes) used primarily for their accommodation are to be properly constructed and efficiently ventilated so as to prevent accumulation of flammable gas.

6.1.3 Starter batteries are to be located as close as practicable to the engine or engines served.

6.1.4 Accumulator batteries shall not be located in sleeping quarters except where hermetically sealed to the satisfaction of the Society.

6.1.5 Lead-acid batteries and alkaline batteries are not to be installed in the same compartment (room, locker, box), unless of valve-regulated sealed type.

6.2 Large vented batteries

6.2.1 Batteries connected to a charging device of power exceeding 2 kW, calculated from the maximum obtainable charging current and the nominal voltage of the battery (hereafter referred to as "large batteries") are to be installed in a room assigned to batteries only.

Where this is not possible, they may be arranged in a suitable locker on deck.

6.2.2 Rooms assigned to large batteries are to be provided with mechanical exhaust ventilation.

Natural ventilation may be employed for boxes located on open deck.

6.2.3 The provisions of [6.2.1] and [6.2.2] also apply to several batteries connected to charging devices of total power exceeding 2 kW calculated for each one as stated in [6.2.1].

6.3 Moderate vented batteries

6.3.1 Batteries connected to a charging device of power between 0,2 kW and 2 kW calculated as stated in [6.2.1] (hereafter referred to as "moderate batteries") are to be arranged in the same manner as large batteries or placed in a box or locker in suitable locations such as machinery spaces, storerooms or similar spaces. In machinery spaces and similar well-ventilated compartments, these batteries may be installed without a box or locker provided they are protected from falling objects, dripping water and condensation where necessary.

6.3.2 Rooms, lockers or boxes assigned to moderate batteries are to be provided with natural ventilation or mechanical exhaust ventilation, except for batteries installed without a box or locker (located open) in well-ventilated spaces.

6.3.3 The provisions of [6.3.1] and [6.3.2] also apply to several batteries connected to charging devices of total power between 0,2 kW and 2 kW calculated for each one as stated in [6.2.1].

6.4 Small vented batteries

6.4.1 Batteries connected to a charging device of power less than 0,2 kW calculated as stated in [6.2.1] (hereafter referred to as "small batteries") are to be arranged in the same manner as moderate or large batteries, or without a box or locker, provided they are protected from falling objects, or in a box in a ventilated area.

6.4.2 Boxes for small batteries may be ventilated only by means of openings near the top to permit escape of gas.

6.5 Ventilation

6.5.1 The ventilation of battery compartments is to be independent of ventilation systems for other spaces.

6.5.2 The quantity of air expelled (by natural or forced ventilation) for compartments containing vented type batteries is to be at least equal to:

$$Q = 110 \cdot I \cdot n$$

where:

Q : Quantity of air expelled, in litres per hour

I : Maximum current delivered by the charging equipment during gas formation, but not less than one quarter of the maximum obtainable charging current in amperes

n : Number of cells in series.

6.5.3 The quantity of air expelled (by natural or forced ventilation) for compartments containing valve-regulated sealed batteries is to be at least 25% of that given in [6.5.2].

6.5.4 Ducts are to be made of a corrosion-resisting material or their interior surfaces are to be painted with corrosion-resistant paint.

6.5.5 Adequate air inlets (whether connected to ducts or not) are to be provided near the floor of battery rooms or the bottom of lockers or boxes (except for that of small batteries).

Air inlet may be from the open air or from another space (for example from machinery spaces).

6.5.6 Exhaust ducts of natural ventilation systems:

a) are to be run directly from the top of the compartment to the open air above (they may terminate in the open or in well-ventilated spaces)

b) are to terminate not less than 90 cm above the top of the battery compartment

c) are to have no part more than 45° from the vertical

d) are not to contain appliances (for example for barring flames) which may impede the free passage of air or gas mixtures.

Where natural ventilation is impracticable or insufficient, mechanical exhaust ventilation is to be provided.

6.5.7 In mechanical exhaust ventilation systems:

a) electric motors are to be outside the exhaust ducts and battery compartment and are to be of safe type if installed within 3 m from the exhaust of the ventilation duct

b) fans are to be so constructed and of a material such as to render sparking impossible in the event of the impeller touching the fan casing

c) steel or aluminium impellers are not to be used

d) the system is to be interlocked with the charging device so that the battery cannot be charged without ventilation (trickle charge may be maintained)

e) a temperature sensor is to be located in the battery compartment to monitor the correct behaviour of the battery in cases where the battery element is sensitive to temperature.

6.5.8 For natural ventilation systems for deck boxes:

a) holes for air inlet are to be provided on at least two opposite sides of the box

b) the exhaust duct is to be of ample dimensions

c) the duct is to terminate at least 1,25 m above the box in a goose-neck or mushroom-head or the equivalent

d) the degree of protection is to be in accordance with Sec 3, Tab 2.

SECTION 12 INSTALLATION

1 General

1.1 Protection against injury or damage caused by electrical equipment

1.1.1 All electrical equipment is to be so installed as not to cause injury when handled or touched in the normal manner.

1.1.2 All electrical equipment is to be installed in such a way that live parts cannot be inadvertently touched, unless supplied at a safety voltage.

1.1.3 For protective earthing as a precaution against indirect contact, see [2].

1.1.4 Equipment is to be installed so as not to cause, or at least so as to reduce to a minimum, electromagnetic interference.

1.2 Protection against damage to electrical equipment

1.2.1 Electrical equipment is to be so placed that as far as practicable it is not exposed to risk of damage from water, steam, oil or oil vapours.

1.2.2 The air supply for internal ventilation of electrical equipment is to be as clean and dry as practicable; cooling air for internal ventilation is not to be drawn from below the floor plates in engine .

1.2.3 Equipment is to be so mounted that its enclosing arrangements and the functioning of the built-in equipment will not be affected by distortions, vibrations and movements of the yacht's structure or by other damage liable to occur.

1.2.4 If electrical fittings, not of aluminium, are attached to aluminium, suitable provision is to be made to prevent galvanic corrosion.

1.3 Accessibility

1.3.1 Equipment is to be so installed that sufficient space is available for inspection and maintenance as required for all its parts (see [6.1.3]).

2 Earthing of non-current carrying parts

2.1 Parts which are to be earthed

2.1.1 Exposed metal parts of both fixed and portable electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live and similar metal parts inside non-metallic enclosures are to be earthed unless the machines or equipment are:

a) supplied at a voltage not exceeding 50 V direct current or 50 V, root mean square between conductors, achieved without the use of auto-transformers (safety voltage); or
b) supplied at a voltage not exceeding 250 V by safety isolating transformers supplying one consuming device only; or
c) constructed in accordance with the principle of double insulation.

2.1.2 To minimise shock from high frequency voltage induced by the radio transmitter, handles, handrails and other metal elements on the bridge or upper decks are to be in electrical connection with the hull or superstructures.

2.2 Methods of earthing

2.2.1 Metal frames or enclosures of apparatus and electrical machinery may be fixed to, and in metallic contact with, the yacht's structure, provided that the surfaces in contact are clean and free from rust, scale or paint when installed and are firmly bolted together.

2.2.2 For metal frames or enclosures which are not earthed as specified in [2.2.1], earthing connections complying with [2.3] and [2.4] are to be used.

2.2.3 For requirements regarding the earthing of coverings of cables and the mechanical protection of cables, see [7.11] and [7.12].

2.3 Earthing connections

2.3.1 Every earthing connection is to be of copper or other corrosion-resistant material and is to be securely installed and protected, where necessary, against damage and electrolytic corrosion.

2.3.2 The nominal cross-sectional area of each copper earthing connection is to be not less than that required in Tab 1.

Earthing connections of other metals are to have conductance at least equal to that specified for a copper earthing connection.

Table 1 : Cross-sectional area of earth-continuity conductors and earthing connections

<table>
<tr><th colspan="2">Type of earthing connection</th><th>Cross-sectional area of associated current carrying conductor</th><th colspan="2">Minimum cross-sectional area of copper earthing connection</th></tr>
<tr><td>1</td><td>Earth-continuity conductor in flexible cable or flexible cord</td><td>any</td><td colspan="2">Same as current carrying conductor up to and including 16 mm^2 and one half above 16 mm^2 but at least 16 mm^2</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Earth-continuity conductor incorporated in fixed cable</td><td rowspan="3">any</td><td colspan="2">a) for cables having an insulated earth-continuity conductor
• a cross-section equal to the main conductors up to and including 16 mm^2, but minimum 1,5 mm^2
• a cross-section not less than 50% of the cross-section of the main conductor when the latter is more than 16 mm^2, but at least 16 mm^2
b) for cables with a bare earth wire in direct contact with the lead sheath</td></tr>
<tr><td>Cross-section of main conductor mm^2</td><td>Earthing connection mm^2</td></tr>
<tr><td>1 ÷ 2,5
4 ÷ 6</td><td>1
1,5</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">Separate fixed earthing conductor</td><td>≤ 2,5 mm^2</td><td colspan="2">Same as current carrying conductor subject to minimum of 1,5 mm^2 for stranded earthing connection or 2,5 mm^2 for unstranded earthing connection</td></tr>
<tr><td>> 2,5 mm^2 but ≤ 120 mm^2</td><td colspan="2">One half the cross-sectional area of the current carrying conductor, subjected to a minimum of 4 mm^2</td></tr>
<tr><td>> 120 mm^2</td><td colspan="2">70 mm^2</td></tr>
</table>

2.3.3 Metal parts of portable appliances are to be earthed, where required (see [2.1.1]), by means of an earth-continuity conductor in the flexible supply cable or cord, which has the cross-sectional area specified in Tab 1 and which is earthed, for example, through the associated plug and socket.

2.3.4 In no circumstances is the lead sheathing or armour of cables to be relied upon as the sole means of earthing.

2.4 Connection to the structure

2.4.1 In case of yachts with metallic construction every connection of an earth-continuity conductor or earthing lead to the yacht’s structure is to be secured by means of a screw of brass or other corrosion-resistant material of diameter not less than 6 mm.

2.4.2 Such earthing connection is not to be used for other purposes.

2.4.3 The connection described in [2.4.1] is to be located in an accessible position where it may readily be checked.

2.4.4 In case of yacht of non metallic construction, where earthing connection is provided, a conductor is to be provided with the function of collector connected to a specific earthing plate. The earthing plate is to be a plate, free from paint, having a thickness of at least 2 mm and a surface area not less than 0,25 m2, fixed to the hull below the lowest waterline so as to remain fully submerged in any listing or heeling condition. The earthing plate is to be made of copper or other conductive material, compatible with sea water and having a surface area such as to give a resistance equivalent to that of a copper earthing connection. The formation of electrochemical couples with other immersed metallic materials is to be avoided which could cause electrolytic corrosion..

2.5 Earthed distribution systems

2.5.1 The system earthing of earthed distribution systems is to be effected by means independent of any earthing arrangements of non-current carrying parts and is to be connected to the hull at one point only.

2.5.2 In an earthed distribution system in which the earthing connection does not normally carry current, this connection is to conform with the requirements of [2.3], except that the lower limit of 70 mm^2 (see Tab 1) does not apply.

2.5.3 In a distribution system with hull return, the system earthing connection is to have at least the same cross-sectional area as the feeder lines.

2.5.4 The earthing connection is to be in an accessible position where it may readily be inspected and disconnected for insulation testing.

2.6 Aluminium superstructures

2.6.1 When aluminium superstructures are insulated from the steel hull to prevent electrolytic corrosion, they are to be secured to the hull by means of a separate bonding connection.

2.6.2 The connections are to be adequately close together and are to have a resistance less than 0.1 Ω.

2.6.3 The connections are to be located where they may readily be inspected.

3 Rotating machines

3.1

3.1.1 Every rotating machine is preferably to be installed with the shaft in the fore-and-aft direction. Where a rotating machine of 100 kW and over is installed athwart, or vertically, it is to be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand the rolling specified in Sec 2, Tab 4.

4 Semiconductor convertors

4.1 Semiconductor power convertors

4.1.1 Naturally air-cooled semiconductor convertors are to be installed such that the circulation of air to and from the stacks or enclosures is not impeded and that the temperature of the cooling inlet air to convertor stacks does not exceed the ambient temperature for which the stacks are specified.

5 Vented type storage batteries

5.1 General

5.1.1 Batteries are to be arranged so that each cell or crate of cells is accessible from the top and at least one side to permit replacement and periodical maintenance.

5.1.2 Cells or crates are to be carried on insulating supports of material non-absorbent to the electrolyte (e.g. treated wood).

5.1.3 Cells are to be securely chocked by means of insulating material non-absorbent to the electrolyte, e.g. strips of treated wood. Special mechanical precautions are to be taken to prevent the emergency battery fron being damaged by the shock due to a collision.

5.1.4 Provision is to be made for the free circulation of air.

5.2 Protection against corrosion

5.2.1 The interior of battery compartments (rooms, lockers, boxes) including all metal parts subject to the electrolyte is to be protected against the deteriorating effect of the latter by electrolyte-resistant coating or other equivalent means, unless corrosion-resistant materials are used.

5.2.2 Interior surfaces of metal shelves for battery cells, whether or not grouped in crates or trays, are to be protected by a lining of electrolyte-resistant material, watertight and carried up to at least 75 mm on all sides. In particular, linings are to have a minimum thickness of 1,5 mm, if of lead sheet for lead-acid batteries, and of 0,8 mm, if of steel for alkaline batteries.

Alternatively, the floor of the room or locker is to be lined as specified above to a height of at least 150 mm.

5.2.3 Battery boxes are to be lined in accordance with [5.2.2] to a height of at least 75 mm.

6 Switchgear and controlgear assemblies

6.1 Main switchboard

6.1.1 The main switchboard is to be so arranged as to give easy access as may be needed to apparatus and equipment, without danger to personnel.

6.1.2 An unobstructed space is to be left in front of the switchboard wide enough to allow access for operation; such width is generally about 1 metre.

When withdrawable equipment is contained in the switchboard, the width of the space is to be not less than 0,5 m when the equipment is fully withdrawn.

Reduced widths may be considered in specific situation.

6.1.3 Where necessary, an unobstructed space is to be provided at the rear of the switchboard ample to permit maintenance; in general, the width of this passage is to be not less than 0,6 m, except that this may be reduced to 0,5 m in way of stiffeners and frames, and the height sufficient for the operation foreseen.

6.1.4 Where the switchboard is open at the rear, the rear space in [6.1.3] is to form a locked space provided at each end with an access door. The required IP protection for the corresponding location is to be fulfilled.

6.1.5 If necessary, the clear height above the switchboard specified by the manufacturer is to be maintained for pressure relief in the event of a short-circuit.

6.1.6 When the voltage exceeds the safety voltage, non-conducting mats or gratings are to be provided at the front and rear of the switchboard as necessary.

6.1.7 Piping and conduits are not to be installed directly above or in the vicinity of switchboards and controlgear assemblies.

Where this is unavoidable, pipes and conduits are to have welded joints only or to be provided with protection against spray from steam or pressurised liquids or dripping.

6.2 Emergency switchboard

6.2.1 For the installation of the emergency switchboard, the same requirements apply as given in [6.1] for the installation of the main switchboard.

6.3 Distribution boards

6.3.1

For the installation of distribution boards, the same requirements apply, as far as applicable, as given in [6.1] for the installation of the main switchboard.

7 Cables

7.1 General

7.1.1 Cables having insulating materials with different maximum permissible conductor temperatures are not to be bunched together.

Where this is not practicable, the cables are to be so installed that no cable reaches a temperature higher than its rating.

7.1.2 Cables having a protective covering which may damage the covering of more vulnerable cables are not to be bunched with the latter.

7.1.3 Cables having a bare metallic sheath (e.g. of copper) or braid or armour are to be installed in such a way that galvanic corrosion by contact with other metals is prevented.

7.1.4 All cables and wiring external to equipment are to be so installed as not to impair their original flame-retarding properties.

To this end, the following methods may be used:

a) the use of cables which have been tested in accordance with IEC Publication 332-3 Category A or an equivalent test procedure for cables installed in bunches, or

b) the use of fire stops having at least B0 penetrations fitted as follows (see Fig 1, Fig 2, Fig 3 and Fig 4):
   - cable entries at the main and emergency switchboard
   - where cables enter engine control rooms
   - cable entries at centralised control panels for propulsion machinery and essential auxiliaries
   - at each end of totally enclosed cable trunks
   - at every every deck for verticals runs and every 7 metres for horizontal runs in enclosed and semi-enclosed spaces

c) the use of fire protection coating applied to at least 1 metre in every 2 metres on horizontal cable runs and over the entire length of vertical cable runs for cables installed in enclosed and semi-enclosed spaces.

The cable penetrations are to be installed in steel plates of at least 3 mm thickness extending all around to twice the largest dimension of the cable run for vertical runs and once for horizontal runs, but need not extend through ceilings, decks, bulkheads or solid sides of trunks. These precautions apply in particular to bunches of 5 or more cables in areas with a high fire risk (such as Category A machinery spaces, galleys etc.) and to bunches of more than 10 cables in other areas.

7.2 Radius of bend

7.2.1 The internal radius of bend for the installation of cables is to be chosen according to the type of cable as recommended by the manufacturer.

Its value is generally to be not less than the figure given in Tab 2.

7.2.2 Where the installation of cables across expansion joints is unavoidable, the minimum internal radius of the loop at the end of the travel of the expansion joint is to be not less than 12 times the external diameter of the cable.

Figure 1 : Totally enclosed trunks

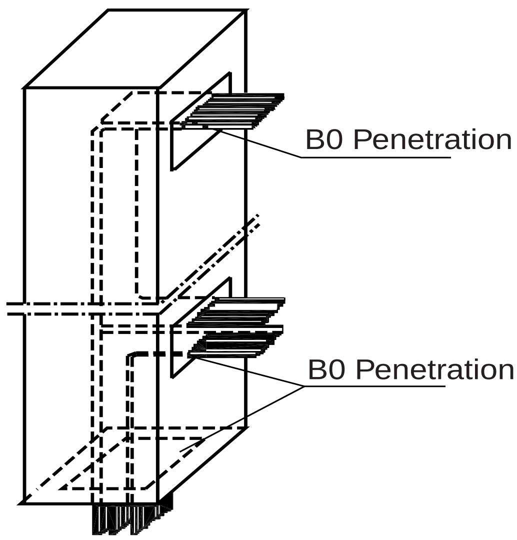


Table 2 : Bending radii

Cable construction		Overall diameter of cable (D)	Minimum internal radius of bend
Insulation	Outer covering		
Thermoplastic or thermosetting with circular copper conductors	Unarmoured or unbraided	≤ 25 mm	4 D
		> 25 mm	6 D
	Metal braid screened or armoured	Any	6 D
	Metal wire armoured Metal tape armoured or metal-sheathed	Any	6 D
	Composite polyester/metal laminate tape screened units or collective tape screening	Any	8 D
Thermoplastic or thermosetting with shaped copper conductors	Any	Any	8 D

Figure 2 : Non-totally enclosed trunks, vertical

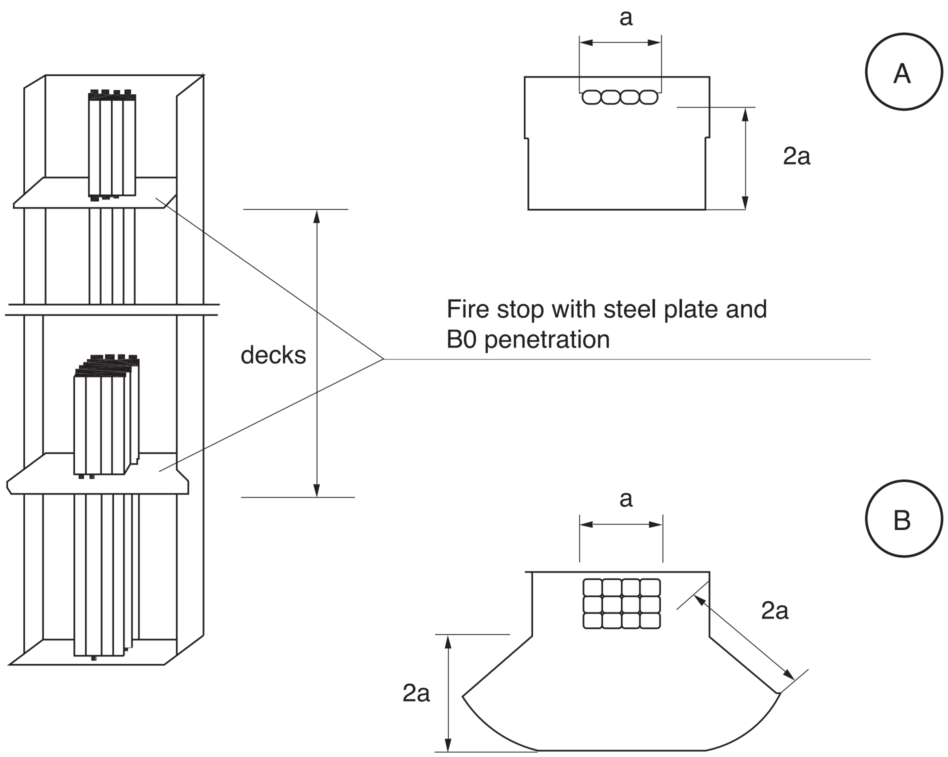


Figure 3 : Non-totally enclosed trunks, horizontal

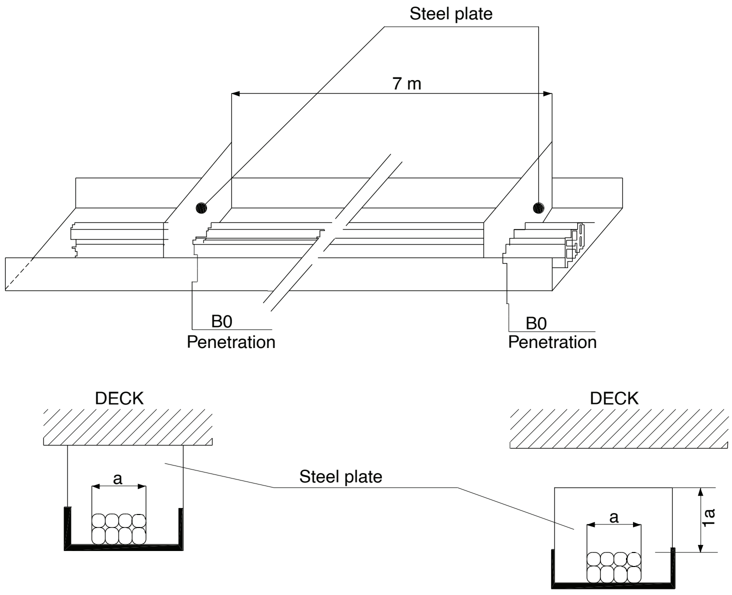
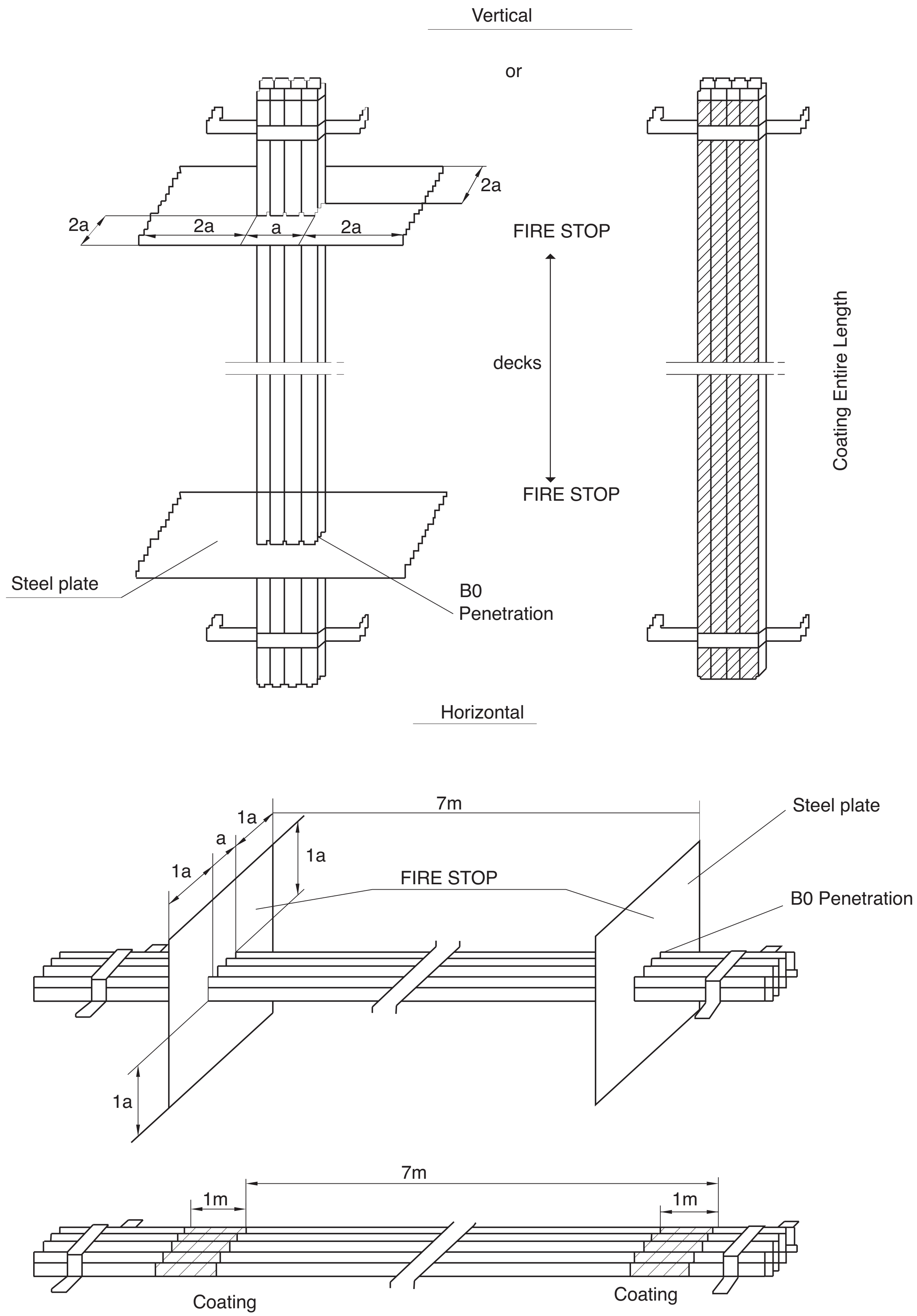


Figure 4 : Open cables runs



7.3 Fixing of cables

7.3.1 Cables shall be installed and supported in such a manner as to avoid chafing or other damage.

7.3.2 The supports (tray plates, separate support brackets or hanger ladders) and the corresponding accessories are to be of robust construction and of corrosion-resistant material or suitably treated before erection to resist corrosion.

When cables are installed directly on aluminium structures, fixing devices of aluminium or suitably treated steel are to be used.

For mineral-insulated cables with copper sheath, fixing devices in contact with the sheath are to be of copper alloy.

7.3.3 With the exception of cables installed in pipes, conduits, trunkings or special casings, cables are to be fixed by means of clips, saddles or straps of suitable material, in order to tighten the cables without their coverings being damaged.

7.3.4 Cable clips or straps made from a material other than metal are to be manufactured of a flame-retardant material.

7.3.5 The distances between fastenings and between supports are to be suitably chosen according to the type and number of cables and the probability of vibration.

7.3.6 When cables are fixed by means of clips or straps made from a material other than metal and these cables are not laid on top of horizontal cable supports (e.g. in the case of vertical installation), suitable metal clips or saddles spaced not more than 1 metre apart are to be used in addition in order to prevent the release of cables during a fire.

7.3.7 Suspended cables of fire-resisting type are to be fixed by means of steel straps spaced not more than 500 mm apart.

7.4 Mechanical protection

7.4.1 Cables exposed to risk of mechanical damage are to be protected by metal casing, profiles or grids or enclosed in metal pipes or conduits, unless the cable covering (e.g. armour or sheath) provides adequate mechanical protection.

7.4.2 In situations where there would be an exceptional risk of mechanical damage, e.g. in holds, storage spaces, etc., cables are to be protected by metal casing, trunkings or conduits, even when armoured, if the yacht’s structure or attached parts do not afford sufficient protection for the cables.

7.4.3 For the protection of cables passing through decks, see [7.5.3].

7.4.4 Metal casing used for mechanical protection of cables is to be effectively protected against corrosion.

7.5 Penetrations of bulkheads and decks

7.5.1 If cables have to pass without adequate support through non-watertight bulkheads and generally through holes drilled in sheets of structural steel, these holes are to be fitted with glands or bushings of suitable material.

7.5.2 If cables have to pass through a watertight bulkhead or deck, the penetration is to be effected in a watertight manner.

Either suitable individual watertight glands for single cables or boxes containing several cables and filled with a flame-retardant packing may be used for this purpose.

Whichever type of penetration is used, the watertight integrity of the bulkheads or deck is to be maintained.

7.5.3 Cables passing through decks and continuing vertically are to be protected against mechanical damage to a suitable height above the deck.

7.5.4 Where cables pass through bulkheads or decks separating areas with a risk of explosion, arrangements are to be such that hazardous gas or dust cannot penetrate through openings for the passage of cables into other areas.

7.5.5 Where cables pass through a bulkhead or deck which is required to have some degree of fire integrity, penetration is to be so effected as to ensure that the required degree of fire integrity is not impaired.

7.6 Expansion joints

7.6.1 If there is reason to fear that a tray plate, pipe or conduit may break because of the motion of the yacht, different load conditions and temperature variations, appropriate expansion joints are to be provided.

This may apply in particular in the case of cable runs on the weather deck.

7.7 Cables in closed pipes or conduits

7.7.1 Closed pipes or conduits are to have such internal dimensions and radius of bend as will permit the easy drawing in and out of the cables which they are to contain; the internal radius of bend is to be not less than that permitted for cables and, for pipes exceeding 63 mm external diameter, not less than twice the external diameter of the pipe where this value is greater.

7.7.2 Closed pipes and conduits are to be suitably smooth on the interior and are to have their ends shaped or bushed in such a way as not to damage the cable covering.

7.7.3 The space factor (ratio of the sum of the cross-sectional areas corresponding to the external diameters of the cables to the internal cross-sectional areas of the pipe or conduit) is to be not greater than 0,4.

7.7.4 If necessary, openings are to be provided at the highest and lowest points so as to permit air circulation and ensure that the heat from the cables can be dissipated, and to obviate the possibility of water accumulating at any part of the pipe or conduit.

7.7.5 Vertical trunking for electrical cables is to be so constructed as not to jeopardise the required passive fire protection between the spaces.

7.7.6 Metal pipes or conduits are to be protected against corrosion.

7.7.7 Non-metallic pipes or conduits are to be flame-retardant.

7.8 Cables in casings or trunking and conduits with removable covers

7.8.1 Covers are to be removable and when they are open, cables are to be accessible.

7.8.2 Materials used are to comply with [7.7.6] and [7.7.7].

7.8.3 If the fixing of covers is by means of screws, the latter are to be of non-rusting material and arranged so as not to damage the cables.

7.8.4 Means are to be provided to ensure that the heat from the cables can be dissipated and water accumulation is avoided (see [7.7.4]).

7.9 Cable ends

7.9.1 Terminations in all conductors are to be so made as to retain the original electrical, mechanical, flame-retarding properties of the cable.

7.9.2 Where mechanical clamps are not used, the ends of all conductors having a cross-sectional area greater than 4 mm^2 are to be fitted with soldering sockets or compression-type sockets of sufficient size to contain all the strands of the conductor.

7.9.3 Cables not having a moisture-resistant insulation (e.g. mineral-insulated) are to have their ends effectively sealed against ingress of moisture.

7.10 Joints and tappings (branch circuit)

7.10.1 Cable runs are normally not to include joints. Where absolutely necessary, cable joints are to be carried out by a junction method with rebuilding of the insulation and protective coverings.

7.10.2 Joints in all conductors are to be so made as to retain the original electrical (continuity and isolation), mechanical (strength and protection), flame-retarding and, where necessary, fire-resisting properties of the cable.

7.10.3 Tappings (branch circuits) are to be made via suitable connections or in suitable boxes of such design that the conductors remain adequately insulated and protected from atmospheric action and are fitted with terminals or busbars of dimensions appropriate to the current rating.

7.10.4 Cables for safety voltages are not to terminate in the same connection boxes as cable for higher voltages unless separated by suitable means.

7.11 Earthing and continuity of metal coverings of cables

7.11.1 All metal coverings of cables are to be electrically connected to the metal hull of the yacht.

7.11.2 Metal coverings are generally to be earthed at both ends of the cable, except for [7.11.3] and [7.11.4].

7.11.3 Single-point earthing is admitted for final sub-circuits (at the supply end), except for those circuits located in areas with a risk of explosion.

7.11.4 Earthing is to be at one end only in those installations (mineral-insulated cables, intrinsically safe circuits, control circuits (see Ch 3, Sec 5), etc.) where it is required for technical or safety reasons.

7.11.5 Metal coverings of single-core a.c. cables and special d.c. cables with high "ripple" content (e.g. for thyristor equipment) are to be earthed at one point only (e.g. at the mid-point).

7.11.6 The electrical continuity of all metal coverings of cables throughout the length of the latter, particularly at joints and tappings, is to be ensured.

7.11.7 The metal covering of cables may be earthed by means of glands intended for the purpose and so designed as to ensure an effective earth connection.

The glands are to be firmly attached to, and in effective electrical contact with, a metal structure earthed in accordance with these requirements.

7.11.8 The metal covering of cables may also be earthed by means of clamps or clips of corrosion-resistant material making effective contact with the covering and earthed metal.

7.12 Earthing and continuity of metal pipes, conduits and trunking or casings

7.12.1 Metal casings, pipes, conduits and trunking are to be effectively earthed.

7.12.2 Pipes or conduits may be earthed by being screwed into a metal enclosure, or by nuts on both sides of the wall of a metallic enclosure, provided the surfaces in contact are clean and free from rust, scale or paint and that the enclosure is in accordance with these requirements on earthing.

The connection is to be painted immediately after assembly in order to inhibit corrosion.

7.12.3 Pipes and conduits may be earthed by means of clamps or clips of corrosion-resistant metal making effective contact with the earthed metal.

7.12.4 Pipes, conduits or trunking together with connection boxes of metallic material are to be electrically continuous.

7.12.5 All joints in metal pipes and conduits used for earth continuity are to be soundly made and protected, where necessary, against corrosion.

7.12.6 Individual short lengths of pipes or conduits need not be earthed.

7.13 Precautions for single-core cables for a.c.

7.13.1 For the earthing of metal coverings see [7.11.5].

7.13.2 Where it is necessary to use single-core cables for alternating current circuits rated in excess of 20 A, the requirements of [7.13.3] to [7.13.7] are to be complied with.

7.13.3 Conductors belonging to the same circuit are to be contained within the same pipe, conduit or trunking, unless this is of non-magnetic material.

7.13.4 Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.

7.13.5 In the installation of two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits, or three-phase and neutral circuits, the cables are to be in contact with one another, as far as possible. In any event, the distance between the external covering of two adjacent cables is to be not greater than one diameter.

7.13.6 When single-core cables having a current rating greater than 250 A are installed near a steel bulkhead, the clearance between the cables and the bulkhead is to be at least 50 mm, unless the cables belonging to the same circuit are installed in trefoil twisted formation.

7.13.7 Magnetic material is not to be used between single-core cables of a group. Where cables pass through steel plates, all the conductors of the same circuit are to pass through a plate or gland, so made that there is no magnetic material between the cables, and the clearance between the cables and the magnetic material is to be no less than 75 mm, unless the cables belonging to the same circuit are installed in trefoil twisted formation.

7.14 Cables in refrigerated spaces

7.14.1 For the types of cables permitted in refrigerated spaces, see Sec 3, [9.4].

7.14.2 Power cables installed in refrigerated spaces are not to be covered by thermal insulation. Moreover, such cables are not to be placed directly on the face of the refrigerated space unless they have a thermoplastic or elastomeric extruded sheath.

7.14.3 Power cables entering a refrigerated space are to pass through the walls and thermal insulation at right angles, in tubes sealed at each end and protected against oxidation.

7.15 Cables in areas with a risk of explosion

7.15.1 For the types of cables permitted in areas with a risk of explosion, see Sec 3, [10.2].

7.15.2 For penetration of bulkheads or decks separating areas with a risk of explosion, see [7.5.4].

7.15.3 Cables of intrinsically safe circuits are to be separated from the cables of all other circuits (minimum 50 mm).

7.16 Cables in the vicinity of radio equipment

7.16.1 All cables between antennas and transmitters are to be routed separately of any other cable.

7.16.2 Where it is necessary to use single-core cables, the arrangement of conductors is to be such as to avoid complete or partial loops.

7.17 Cables for submerged bilge pumps

7.17.1 See Sec 3, [8.7].

8 Various appliances

8.1 Lighting fittings

8.1.1 Lighting fittings are to be so arranged as to prevent temperature rises which could damage the cables and wiring.

Note 1: Where the temperature of terminals of lighting fittings exceeds the maximum conductor temperature permitted for the supplied cable (see Sec 3, [9.9]), special installation arrangements, such as terminal boxes thermally insulated from the light source, are to be provided.

8.1.2 Lighting fittings are to be so arranged as to prevent surrounding material from becoming excessively hot.

8.1.3 Lighting fittings are to be secured in place such that they cannot be displaced by the motion of the vessel.

8.2 Heating appliances

8.2.1 Space heaters are to be so installed that clothing, bedding and other flammable material cannot come in contact with them in such a manner as to cause risk of fire.

Note 1: To this end, for example, hooks or other devices for hanging garments are not to be fitted above space heaters or, where appropriate, a perforated plate of incombustible material is to be mounted above each heater, slanted to prevent hanging anything on the heater itself.

8.2.2 Space heaters are to be so installed that there is no risk of excessive heating of the bulkheads or decks on which or next to which they are mounted.

8.2.3 Combustible materials in the vicinity of space heaters are to be protected by suitable incombustible and thermal-insulating materials.

8.3 Heating cables and tapes or other heating elements

8.3.1 Heating cables and tapes or other heating elements are not to be installed in contact with combustible materials. Where they are installed close to such materials, they are to be separated by means of a non-flammable material.

9 Electrolytic corrosion

9.1 General

9.1.1 Metallic parts in contact with sea water, such as valves, pipes, engine casings, etc., not otherwise protected against electrolytic corrosion, are to be electrically connected to a copper conductor having the function of collector, connected in turn to sacrificial anodes.

SECTION 13 HIGH VOLTAGE INSTALLATIONS

1 General

1.1 Field of application

1.1.1

The following requirements apply to a.c. three-phase systems with nominal voltage exceeding 1kV, the nominal voltage being the voltage between phases.

If not otherwise stated herein, construction and installation applicable to low voltage equipment generally apply to high voltage equipment.

1.2 Nominal system voltage

1.2.1

The nominal system voltage is not to exceed 15 kV.

Note 1: Where necessary for special application, higher voltages may be accepted by the Society.

1.3 High-voltage, low-voltage segregation

1.3.1

Equipment with voltage above about 1 kV is not to be installed in the same enclosure as low voltage equipment, unless segregation or other suitable measures are taken to ensure that access to low voltage equipment is obtained without danger.

2 System Design

2.1 Distribution

2.1.1 Network configuration for continuity of yacht services

It is to be possible to split the main switchboard into at least two independent sections, by means of at least one circuit breaker or other suitable disconnecting devices, each supplied by at least one generator. If two separate switchboards are provided and interconnected with cables, a circuit breaker is to be provided at each end of the cable.

Services which are duplicated are to be divided between the sections.

2.1.2 Earthed neutral systems

In the event of an earth fault, the current is not to be greater than full load current of the largest generator on the switchboard or relevant switchboard section and not less than three times the minimum current required to operate any device against earth fault.

It is to be assured that at least one source neutral to ground connection is available whenever the system is in the energised mode. Electrical equipment in directly earthed neutral or other neutral earthed systems is to withstand the current due to a single phase fault against earth for the time necessary to trip the protection device.

2.1.3 Neutral disconnection

Means of disconnection are to be fitted in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance and for insulation resistance measurement.

2.1.4 Hull connection of earthing impedance

All earthing impedances are to be connected to the hull. The connection to the hull is to be so arranged that any circulating currents in the earth connections do not interfere with radio, radar, communication and control equipment circuits.

2.1.5 Divided systems

In systems with neutral earthed, connection of the neutral to the hull is to be provided for each section.

2.2 Degrees of protection

2.2.1 General

Each part of the electrical installation is to be provided with a degree of protection appropriate to the location, as a minimum the requirements of IEC 60092-201.

2.2.2 Rotating machines

The degree of protection of enclosures of rotating electrical machines is to be at least IP 23.

The degree of protection of terminals is to be at least IP44.

For motors installed in spaces accessible to unqualified personnel, a degree of protection against approaching or contact with live or moving parts of at least IP4X is required.

2.2.3 Transformers

The degree of protection of enclosures of transformers is to be at least IP23.

For transformers installed in spaces accessible to unqualified personnel a degree of protection of at least IP4X is required.

For transformers not contained in enclosures, see [8.1].

2.2.4 Switchgear, controlgear assemblies and convertors

The degree of protection of metal enclosed switchgear, controlgear assemblies and static convertors is to be at least IP32. For switchgear, control gear assemblies and static convertors installed in spaces accessible to unqualified personnel, a degree of protection of at least IP4X is required.

2.3 Insulation

2.3.1

In general, for non Type Tested equipment phase-to-phase air clearances and phase-to- earth air clearances between non-insulated parts are to be not less than those specified in Tab 1.

Intermediate values may be accepted for nominal voltages provided that the next highest air clearance is observed.

In the case of smaller distances, an appropriate voltage impulse test is to be applied.

Table 1 : Minimum clearances

Rated voltage, in kV	Minimum clearance, in mm
3 - 3,3	55
6 - 6,6	90
10 - 11	120
15	160

2.3.2

Creepage distances between live parts and between live parts and earthed metal parts are to be in accordance with IEC 60092-503 for the nominal voltage of the system, the nature of the insulation material and the transient overvoltage developed by switch and fault conditions.

2.4 Protection

2.4.1 Faults on the generator side of the circuit breaker

Protective devices are to be provided against phase-to-phase faults in the cables connecting the generators to the main switchboard and against interwinding faults within the generators. The protective devices are to trip the generator circuit breaker and to automatically de-excite the generator.

In distribution systems with a neutral earthed, phase to earth faults are also to be treated as above.

2.4.2 Faults to earth

Any earth fault in the system is to be indicated by means of a visual and audible alarm.

In low impedance or direct earthed systems provision is to be made to automatically disconnect the faulty circuits. In high impedance earthed systems, where outgoing feeders will not be isolated in case of an earth fault, the insulation of the equipment is to be designed for the phase to phase voltage (see Note 1).

A system is defined effectively earthed (low impedance) when earthing factor is lower than 0,8. A system is defined non-effectively earthed (high impedance) when earthing factor is higher than 0,8.

Note 1: Earthing factor is defined as the ratio between the phase to earth voltage of the health phase and the phase to phase voltage. This factor may vary between 1/√3and 1.

2.4.3 Power transformers

Power transformers are to be provided with overload and short circuit protection.

When transformers are connected in parallel, tripping of the protective devices on the primary side is to automatically trip the switch connected on the secondary side.

2.4.4 Voltage transformers for control and instrumentation)

Voltage transformers are to be provided with overload and short circuit protection on the secondary side.

2.4.5 Fuses

Fuses are not to be used for overload protection.

2.4.6 Low voltage systems

Lower voltage systems supplied through transformers from high voltage systems are to be protected against overvoltages. This may be achieved by:

a) direct earthing of the lower voltage system

b) appropriate neutral voltage limiters

c) earthed screen between the primary and secondary windings of transformers.

2.4.7 Arc Detection System

In order to limit the consequences of an internal arc to the high voltage main switchboard, measures may be adopted for a rapid fault-clearance times initiated by an Arc Detection System by means of detectors, e.g. sensitive to light, pressure or heat.

Where the Arc Detection System is fitted, the following requirements are to be complied with:

a) Arc Detection Systems for each section of the main switchboard are to be independent

b) The total disconnection of one section of the main switchboard, as a consequence of an arc fault, is permitted only when it is demonstrated that an arc fault located in any compartments of the switchboard (e.g. cable compartments, circuit breaker compartment, etc.) may jeopardise the operation of the entire switchboard

c) The arrangement of the power supplies are to be in such a way that a failure inside the Arc Detection System will not cause the loss of generators and/or essential services.

d) A failure analysis is to be carried out using appropriate means (e.g. FMEA) to demonstrate that, for single failures, system will fail to safety and that system in operation will not be lost or degraded beyond acceptable performance criteria. Faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response.

e) The Arc Detection System, including relevant arc detectors, is to be type tested or type approved according to the tests listed in Ch 3, Sec 6, Tab 1.

3 Rotating machinery

3.1 Stator windings of generators

3.1.1

Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

3.2 Temperature detectors

3.2.1

Rotating machinery is to be provided with temperature detectors in its stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit.

If embedded temperature detectors are used, means are to be provided to protect the circuit against overvoltage.

3.3 Tests

3.3.1

In addition to the tests normally required for rotating machinery, a high frequency high voltage test in accordance with IEC 60034-15 is to be carried out on the individual coils in order to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

4 Power Transformers

4.1 General

4.1.1

Dry type transformers are to comply with IEC 60076-11.

Liquid cooled transformers are to comply with the applicable Parts of the IEC 60076 Series.

Oil immersed transformers are to be provided with the following alarms and protection:

- liquid level (Low) - alarm
- liquid temperature (High) - alarm
- liquid level (Low) - trip or load reduction
- liquid temperature (High) - trip or load reduction
- gas pressure relay (High) - trip

5 Cables

5.1 General

5.1.1

Cables are to be constructed in accordance with IEC 60092-353 and 60092-354 or other equivalent Standard.

6 Fuses

6.1 General

6.1.1

Fuses are to be constructed in accordance with IEC 60282-1 or other equivalent Standard.

7 Switchgear and controlgear assemblies

7.1 General

7.1.1

Switchgear and controlgear assemblies are to be constructed according to IEC 62271-200 and the following additional requirements.

7.2 Construction

7.2.1 Mechanical construction

Switchgear is to be of metal - enclosed type in accordance with IEC 62271-200 or of the insulation - enclosed type in accordance with IEC 62271-201.

7.2.2 Locking facilities

Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purposes, key locking of withdrawable circuit breakers and switches and fixed disconnectors is to be possible.

Withdrawable circuit breakers are to be located in the service position so that there is no relative motion between fixed and moving portions.

7.2.3 Shutters

The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawable position the live contacts are automatically covered.

Shutters are to be clearly marked for incoming and outgoing circuits; this is to be achieved with the use of colours or labels.

7.2.4 Earthing and short-circuiting

For maintenance purposes an adequate number of earthing and short-circuiting devices is to be provided to enable circuits to be worked upon with safety.

7.2.5 Internal Arc Classification (IAC)

Switchgear and controlgear assemblies are to be internal arc classified (IAC) in accordance with IEC 62271-200.

Where switchgear and controlgear are accessible by authorized personnel only, Accessibility Type A is sufficient. Where switchgear and controlgear are accessible by non-authorised personnel, accessibility Type B is required.

Installation and location of the switchgear and controlgear is to correspond with its internal arc classification and classified sides (F, L and R).

7.3 Auxiliary systems

7.3.1 Source of supply

If electrical energy and/or physical energy is required for the operation of circuit breakers and switches, a store supply of such energy is to be provided for at least two operations of all the components.

However, the tripping due to overload or short-circuit, and under-voltage is to be independent of any stored electrical energy sources. This does not preclude shunt tripping provided that alarms are activated upon lack of continuity in the release circuits and power supply failures.

7.3.2 Number of supply sources

When external supply is necessary for auxiliary circuits, at least two external sources of supply are to be provided and so arranged that a failure or loss of one source will not cause the loss of more than one generator set and/or set of essential services.

Where necessary, one source of supply is to be from the emergency source of electrical power for the start up from dead condition.

7.4 High voltage test

7.4.1

A power-frequency voltage test is to be carried out on any switchgear and controlgear assemblies. The test procedure and voltages are to be according to IEC 62271-200.

8 Installation

8.1 Electrical equipment

8.1.1

Where equipment is not contained in an enclosure but a room forms the enclosure of the equipment, the access doors are to be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down.

At the entrance to spaces where high-voltage electrical equipment is installed, a suitable marking is to be placed indicating danger of high-voltage. As regards high-voltage electrical equipment installed outside the aforementioned spaces, similar marking is to be provided.

An adequate, unobstructed working space is to be left in the vicinity of high voltage equipment for preventing potential severe injuries to personnel performing maintenance activities. In addition, the clearance between the switchboard and the ceiling/deckhead above is to meet the requirements of the Internal Arc Classification (see [7.2.5]).

8.2 Cables

8.2.1 Runs of cables

In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

8.2.2 Segregation

High voltage cables are to be segregated from cables operating at different voltage ratings; in particular, they are not to be run in the same cable bunch, in the same ducts or pipes, or in the same box.

Where high voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between cables is not to be less than the minimum air clearance for the higher voltage side in [2.3.1]. However, high voltage cables are not to be installed on the same cable tray for cables operating at the nominal system voltage of 1 kV and less.

8.2.3 Installation arrangements

High voltage cables are generally to be installed on carrier plating cable tray when they are provided with a continuous metallic sheath or armour which is effectively bonded to earth; otherwise they are to be installed for their entire length in metallic castings effectively bonded to earth.

8.2.4 Terminations

Terminations in all conductors of high voltage cables are, as far as practicable, to be effectively covered with suitable insulating material. In terminal boxes, if conductors are not insulated, phases are to be separated from earth and from each other by substantial barriers of suitable insulating materials.

High voltage cables of the radial field type, i.e. having a conductive layer to control the electric field within the insulation, are to have terminations which provide electric stress control.

Terminations are to be of a type compatible with the insulation and jacket material of the cable and are to be provided with means to ground all metallic shielding components (i.e. tapes, wires etc).

8.2.5 Marking

High voltage cables are to be readily identifiable by suitable marking.

8.2.6 Test after installation

Before a new high voltage cable installation, or an addition to an existing installation, is put into service a voltage withstand test is to be satisfactorily carried out on each completed cable and its accessories.

The test is to be carried out after an insulation resistance test in accordance with Sec 15, [3.1.1].

For cables with rated voltage (U0/U) above 1,8/3 kV (Um=3,6 kV) an a.c. voltage withstand test is to be carried out upon advice from high voltage cable manufacturer. For this purpose, one of the following test methods are to be used:

a) test for 5 min with the phase-to-phase voltage of the system applied between the conductor and the metallic screen/sheath;
b) test for 24 h with the normal operating voltage of the system.

Alternatively, a d.c. voltage equal to 4 Uo is to be applied for 15 minutes.

For cables with rated voltage (U0/U) up to 1.8/3 kV (Um=3.6 kV) a d.c. voltage equal to 4 Uo is to be applied for 15 minutes.

After completion of the test the conductors are to be connected to earth for a sufficient period in order to remove any trapped electric charge.

An insulation resistance test in accordance with Sec 15, [3.1.1] is then repeated.

SECTION 14 ELECTRIC PROPULSION PLANT

1 General

1.1 Applicable requirements

1.1.1 The following requirements apply to yachts for which the main propulsion plants are provided by at least one electric propulsion motor and its electrical supply. All electrical components of the propulsion plants are to comply with these requirements.

1.1.2 Prime movers are to comply with the requirements of Ch 1, Sec 2.

1.1.3 For the torsional vibration characteristics of the electric propulsion plant, the provisions of Ch 1, Sec 9 apply.

1.1.4 Cooling and lubricating oil systems are to comply with the requirements of Ch 1, Sec 10.

1.1.5 Monitoring and control systems are to comply with the requirements of Chapter 3.

1.1.6 Installations assigned an additional notation for automation are to comply with the requirements of Part F.

1.2 Operating conditions

1.2.1 The normal torque available on the electric propulsion motors for manoeuvring is to be such as to enable the vessel to be stopped or reversed when sailing at its maximum service speed.

1.2.2 Adequate torque margin is to be provided for three-phase synchronous motors to avoid the motor pulling out of synchronism during rough weather and when turning.

1.2.3 When an electric generating plant has a continuous rating greater than the electric propulsion motor rating, means are to be provided to limit the continuous input to the motor. This value is not to exceed the continuous full load torque for which motor and shafts are designed.

1.2.4 The plant as a whole is to have sufficient overload capacity to provide the torque, power and reactive power needed during starting and manoeuvring conditions.

Locked rotor torque which may be required in relation to the operation of the vessel (e.g. for navigation in ice) is to be considered.

1.2.5 The electric motors and shaftline are to be constructed and installed so that, at any speed reached in service, all the moving components are suitably balanced.

2 Design of the propulsion plant

2.1 General

2.1.1 The electrical power for the propulsion system may be supplied from generating sets, dedicated to the propulsion system, or from a central power generation plant, which supplies the yacht's services and electric propulsion.

The minimum configuration of an electric propulsion plant consists of one prime mover, one generator and one electric motor. When the electrical production used for propulsion is independent of the board production, the diesel engines driving the electric generators are to be considered as main engines.

2.1.2 For plants having only one propulsion motor controlled via a static convertor, a standby convertor which it is easy to switch over to is to be provided. Double stator windings with one convertor for each winding are considered as an alternative solution.

2.1.3 In electric propulsion plants having two or more constant voltage propulsion generating sets, the electrical power for the yacht's auxiliary services may be derived from this source. Additional yacht's generators for auxiliary services need not be fitted provided that effective propulsion and the services mentioned in Sec 3, [2.2.3] are maintained with any one generating set out of service.

Where transformers are used to supply the auxiliary services, see Sec 5.

2.1.4 Plants having two or more propulsion generators, two or more static convertors or two or more motors on one propeller shaft are to be so arranged that any unit may be taken out of service and disconnected electrically, without affecting the operation of the others.

2.2 Power supply

2.2.1 Where the plant is intended exclusively for electric propulsion, voltage variations and maximum voltage are to be maintained within the limits required in Sec 2.

2.2.2 In special conditions (e.g. during crash-stop manoeuvres), frequency variations may exceed the limits stipulated in Sec 2 provided that other equipment operating on the same network is not unduly affected.

2.2.3 The electric plant is to be so designed as to prevent the harmful effects of electromagnetic interference generated by semiconductor convertors, in accordance with Sec 2.

2.3 Auxiliary machinery

2.3.1 Propeller/thruster auxiliary plants are to be supplied directly from the main switchboard or from the main distribution board or from a distribution board reserved for such circuits, at the auxiliary rated voltage.

2.3.2 When the installation has one or more lubrication systems, devices are to be provided to ensure the monitoring of the lubricating oil return temperature.

2.3.3 Propelling machinery installations with a forced lubrication system are to be provided with alarm devices which will operate in the event of oil pressure loss.

2.4 Electrical Protection

2.4.1 Automatic disconnections of electric propulsion plants which adversely affect the manoeuvrability of the yacht are to be restricted to faults liable to cause severe damage to the equipment.

2.4.2 The following protection of convertors is to be provided:

- protection against overvoltage in the supply systems to which convertors are connected
- protection against overcurrents in semiconductor elements during normal operation
- short-circuit protection.

2.4.3 Overcurrent protective devices in the main circuits are to be set sufficiently high so that there is no possibility of activation due to the overcurrents caused in the course of normal operation, e.g. during manoeuvring or in heavy seas.

2.4.4 Overcurrent protection may be replaced by automatic control systems ensuring that overcurrents do not reach values which may endanger the plant, e.g. by selective tripping or rapid reduction of the magnetic fluxes of the generators and motors.

2.4.5 In the case of propulsion plants supplied by generators in parallel, suitable controls are to ensure that, if one or more generators are disconnected, those remaining are not overloaded by the propulsion motors.

2.4.6 In three-phase systems, phase-balance protective devices are to be provided for the motor circuit which de-excite the generators and motors or disconnect the circuit concerned.

2.5 Excitation of electric propulsion motor

2.5.1 Each propulsion motor is to have its own exciter.

2.5.2 For plants where only one generator or only one motor is foreseen, each machine is to be provided with a standby static electronic exciter, which it is easy to switch over to.

2.5.3 In the case of multi-propeller propulsion yachts, one standby static electronic exciter which it is easy to switch over to is to be provided.

2.5.4 For the protection of field windings and cables, means are to be provided for limiting the induced voltage when the field circuits are opened. Alternatively, the induced voltage when the field circuits are opened is to be maintained at the nominal design voltage.

2.5.5 In excitation circuits, there is to be no overload protection causing the opening of the circuit, except for excitation circuits with semiconductor convertors.

3 Construction of rotating machines and semiconductor convertors

3.1 Ventilation

3.1.1 Where electrical machines are fitted with an integrated fan and are to be operated at speeds below the rated speed with full load torque, full load current, full load excitation or the like, the design temperature rise is not to be exceeded.

3.1.2 Where electrical machines or convertors are force-ventilated, at least two fans, or other suitable arrangements, are to be provided so that limited operation is possible in the event of one fan failing.

3.2 Protection against moisture and condensate

3.2.1 Machines and equipment which may be subject to the accumulation of moisture and condensate are to be provided with effective means of heating. The latter is to be provided for motors above 500 kW, in order to maintain the temperature inside the machine at about 3°C above the ambient temperature.

3.2.2 Provision is to be made to prevent the accumulation of bilge water, which is likely to enter inside the machine.

3.3 Rotating machines

3.3.1 Electrical machines are to be able to withstand the excess speed which may occur during operation of the yacht.

3.3.2 The design of rotating machines supplied by static convertors is to consider the effects of harmonics.

3.3.3 The winding insulation of electrical machines is to be capable of withstanding the overvoltage which may occur in manoeuvring conditions.

3.3.4 The design of a.c. machines is to be such that they can withstand without damage a sudden short-circuit at their terminals under rated operating conditions.

3.3.5 The obtainable current and voltage of exciters and their supply are to be suitable for the output required during manoeuvring and overcurrent conditions, including short-circuit in the transient period.

3.4 Semiconductor convertors

3.4.1 The following limiting repetitive peak voltages U_{RM} are to be used as a base for each semiconductor valve:

- when connected to a supply specifically for propeller drives:

  $U_{RM} = 1,5\ U_P$

- when connected to a common main supply:

  $U_{RM} = 1,8\ U_P$

  where

  U_P : is the peak value of the rated voltage at the input of the semiconductor convertor.

3.4.2 For semiconductor convertor elements connected in series, the values in [3.4.1] are to be increased by 10%. Equal voltage distribution is to be ensured.

3.4.3 For parallel-connected convertor elements, an equal current distribution is to be ensured.

3.4.4 Means are to be provided, where necessary, to limit the effects of the rate of harmonics to the system and to other semiconductor convertors. Suitable filters are to be installed to keep the current and voltage within the limits given in Sec 2.

4 Control and monitoring

4.1 General

4.1.1 The control and monitoring systems, including programmable electronic systems, are to be type approved, according to Ch 3, Sec 6.

4.2 Power plant control systems

4.2.1 The power plant control systems are to ensure that adequate propulsion power is available, by means of automatic control systems and/or manual remote control systems.

4.2.2 The automatic control systems are to be such that, in the event of a fault, the propeller speed and direction of thrust do not undergo substantial variations.

4.2.3 Failure of the power plant control system is not to cause complete loss of generated power (i.e. blackout) or loss of propulsion.

4.2.4 The loss of power plant control systems is not to cause variations in the available power; i.e. starting or stopping of generating sets is not to occur as a result.

4.2.5 Where power-aided control (for example with electrical, pneumatic or hydraulic aid) is used for manual operation, failure of such aid is not to result in interruption of power to the propeller, any such device is to be capable of purely manual operation.

4.2.6 The control system is to include the following main functions:
- monitoring of the alarms: any event critical for the proper operation of an essential auxiliary or a main element of the installation requiring immediate action to avoid a breakdown is to activate an alarm
- speed or pitch control of the propeller
- shutdown or slow down when necessary.

4.2.7 Where the electric propulsion system is supplied by the main switchboard together with the ’s services, load shedding of the non-essential services and /or power limitation of the electric propulsion is to be provided. An alarm is to be triggered in the event of power limitation or load shedding.

4.2.8 The risk of blackout due to electric propulsion operation is to be eliminated. At the request of the Society, a failure mode and effects analysis is to be carried out to demonstrate the reliability of the system.

4.3 Indicating instruments

4.3.1 In addition to the provisions of Chapter 3 of the Rules, instruments indicating consumed power and power available for propulsion are to be provided at each propulsion remote control position.

4.3.2 The instruments specified in [4.3.3]and [4.3.4] in relation to the type of plant are to be provided on the power control board or in another appropriate position.

4.3.3 The following instruments are required for each propulsion alternator:
- an ammeter on each phase, or with a selector switch to all phases
- a voltmeter with a selector switch to all phases
- a wattmeter
- a tachometer or frequency meter
- a power factor meter or a var-meter or a field ammeter for each alternator operating in parallel
- a temperature indicator for direct reading of the temperature of the stator windings, for each alternator rated above 500 kW.

4.3.4 The following instruments are required for each a.c. propulsion motor:
- an ammeter on the main circuit
- an embedded sensor for direct reading of the temperature of the stator windings, for motors rated above 500 kW
- an ammeter on the excitation circuit for each synchronous motor
- a voltmeter for the measurement of the voltage between phases of each motor supplied through a semiconductor frequency convertor.

4.3.5 Where a speed measuring system is used for control and indication, the system is to be duplicated with separate sensor circuits and separate power supply.

4.3.6 An ammeter is to be provided on the supply circuit for each propulsion semiconductor bridge.

4.4 Alarm system

4.4.1 An alarm system is to be provided, in accordance with the requirements of Chapter 3. The system is to give an indication at the control positions when the parameters specified in [4.4] assume abnormal values or any event occurs which can affect the electric propulsion.

4.4.2 Where an alarm system is provided for other essential equipment or installations, the alarms in [4.4.1] may be connected to such system.

4.4.3

Critical alarms for propulsion may be grouped, but are to be indicated to the bridge separately from other alarms.

4.4.4 The following alarms are to be provided, where applicable:

- high temperature of the cooling air of machines and semiconductor convertors provided with forced ventilation (see Note 1)
- reduced flow of primary and secondary coolants of machines and semiconductor convertors having a closed cooling system with a heat exchanger
- leakage of coolant inside the enclosure of machines and semiconductor convertors with liquid-air heat exchangers
- high winding temperature of generators and propulsion motors, where required (see [4.3])
- low lubricating oil pressure of bearings for machines with forced oil lubrication
- tripping of protective devices against overvoltages in semiconductor convertors (critical alarm)
- tripping of protection on filter circuits to limit the disturbances due to semiconductor convertors
- tripping of protective devices against overcurrents up to and including short-circuit in semiconductor convertors (critical alarm)
- voltage unbalance of three-phase a.c. systems supplied by semiconductor frequency convertors
- earth fault for the main propulsion circuit (see Note 2)
- earth fault for excitation circuits of propulsion machines (see Note 3).

Note 1: As an alternative to the air temperature of convertors or to the airflow, the supply of electrical energy to the ventilator or the temperature of the semiconductors may be monitored.

Note 2: In the case of star connected a.c. generators and motors with neutral points earthed, this device may not detect an earth fault in the entire winding of the machine.

Note 3: This may be omitted in brushless excitation systems and in the excitation circuits of machines rated up to 500 kW. In such cases, lamps, voltmeters or other means are to be provided to detect the insulation status under operating conditions.

4.5 Reduction of power

4.5.1 Power is to be automatically reduced in the following cases:

- low lubricating oil pressure of bearings of propulsion generators and motors
- high winding temperature of propulsion generators and motors
- fan failure in machines and convertors provided with forced ventilation, or failure of cooling system
- lack of coolant in machines and semiconductor convertors
- load limitation of generators or inadequate available power.

4.5.2 When power is reduced automatically, this is to be indicated at the propulsion control position (critical alarm).

4.5.3 Switching-off of the semiconductors in the event of abnormal service operation is to be provided in accordance with the manufacturer’s specification.

5 Installation

5.1 Ventilation of spaces

5.1.1 Loss of ventilation to spaces with forced air cooling is not to cause loss of propulsion. To this end, two sets of ventilation fans are to be provided, one acting as a standby unit for the other. Equivalent arrangements using several independently supplied fans may be considered.

5.2 Cable runs

5.2.1 Instrumentation and control cables are to comply with the requirements of Ch 3, Sec 5.

5.2.2 Where there is more than one propulsion motor, all cables for any one machine are to be run as far as is practicable away from the cables of other machines.

5.2.3 Cables which are connected to the sliprings of synchronous motors are to be suitably insulated for the voltage to which they are subjected during manoeuvring.

6 Tests

6.1 Test of rotating machines

6.1.1 The test requirements are to comply with Sec 4.

6.1.2 For rotating machines, such as synchronous generators and synchronous electric motors, of a power of more than 3 MW, a test program is to be submitted to the Society for approval.

7 Specific requirements for PODs

7.1 General

7.1.1 The requirements for the structural part of a POD are specified in Pt B, Ch 10, Sec 1, [11].

7.1.2 When used as steering manoeuvring system, the POD is to comply with the requirements of Ch 1, Sec 11.

7.2 Rotating commutators

7.2.1 As far as the electrical installation is concerned, the electric motor is supplied by a rotating commutator which rotates with the POD. The fixed part of the power transmission is connected to the yacht supply, which uses the same components as a conventional propulsion system. Sliding contacts with a suitable support are used between the fixed and rotating parts.

7.2.2
Type tests are to be carried out, unless the manufacturer can produce evidence based on previous experience indicating the satisfactory performance of such equipment on board.

7.2.3 A test program is to be submitted to the Society for approval. It is to be to demonstrated that the power transmission and transmission of low level signals are not affected by the environmental and operational conditions prevailing on board. To this end, the following checks and tests are to be considered:

- check of the protection index (I.P.), in accordance with the location of the rotating commutator
- check of the clearances and creepage distances
- check of insulation material (according to the test procedure described in IEC Publication 60112)
- endurance test:

  After the contact pressure and rated current are set, the commutator is subjected to a rotation test. The number of rotations is evaluated taking into consideration the yacht operation and speed rotation control system. The possibility of turning the POD 180° to proceed astern and 360° to return to the original position is to be considered. The commutator may be submitted to cycles comprising full or partial rotation in relation to the use of the POD as steering gear. The voltage drops and current are to be recorded.

  An overload test is to be carried out in accordance with Sec 4 (minimum 150%, 15 seconds)
- check of the behaviour of the sliprings when subjected to the vibration defined in Ch 3, Sec 6

- check of the behaviour of the sliprings, after damp heat test, as defined in Chapter 3, and possible corrosion of the moving parts and contacts

  After the damp heat test, are to be carried out the hereunder listed tests.
- Insulation measurement resistance test. The minimum resistance is to be in accordance with Sec 4, Tab 3.
- Dielectric strength test as defined in Sec 4.

7.3 Electric motors

7.3.1 The thermal losses are dissipated by the liquid cooling of the bulb and by the internal ventilation of the POD. The justification for the evaluation of the heating balance between the sea water and air cooling is to be submitted to the Society.

Note 1: The calculation method used for the evaluation of the cooling system (mainly based on computer programs) is to be documented. The calculation method is to be justified based on the experience of the designer of the system. The results of scale model tests or other methods may be taken into consideration.

7.3.2 Means to adjust the air cooler characteristics are to be provided on board, in order to obtain an acceptable temperature rise of the windings. Such means are to be set following the dock and sea trials.

7.4 Instrumentation and associated devices

7.4.1 Means are to be provided to transmit the low level signals connected to the sensors located in the POD.

7.5 Additional tests

7.5.1 Tests of electric propulsion motors are to be carried out in accordance with Sec 4, and other tests in accordance with Ch 1, Sec 16.

7.5.2 Tests are to be performed to check the validation of the temperature rise calculation.

SECTION 15 TESTING

1 General

1.1 Rule application *(1/1/2025)*

1.1.1 Before a new installation, or any alteration or addition to an existing installation, is put into service, the electrical equipment is to be tested in accordance with [3], [4] and [5] to be read together with Pt A, Ch 2, App.3 equipment testing tables E and N to the satisfaction of the Surveyor in charge.

1.2 Insulation-testing instruments

1.2.1 Insulation resistance may be measured with an instrument applying a voltage of at least 500 V. The measurement will be taken when the deviation of the measuring device is stabilised.

Note 1: Any electronic devices present in the installation are to be disconnected prior to the test in order to prevent damage.

2 Type approved components

2.1

2.1.1

The following components are to be type tested or type approved according to the requirements in the present Chapter 2 and, excluding cables, transformers, rotating machines and converters (but not the relevant electronic control equipment), according to the tests listed in Ch 3, Sec 6, Tab 1, as far as applicable, or in accordance with [2.1.2]:

- electrical cables (internal wiring of equipment excluded)
- transformers
- rotating machines
- electrical convertors
- circuit-breakers, contactors, fuses and fuse-combination units used in power and lighting distribution systems, motor and transformer circuits, overcurrent protective devices
- sensors, alarm panels, electronic protective devices, automatic and remote control equipment, actuators, safety devices for installations intended for essential services (steering, controllable pitch propellers, propulsion machinery, etc.), electronic speed regulators for main or auxiliary engines, electronic devices for alarm, safety and control of electrical convertors for primary essential services and emergency services as defined in Sec 3, [3.7.3]
- programmable electronic systems intended for functions which are subject to classification requirements
- cable trays/protective casings made of plastic materials.

2.1.2 Case by case approval based on submission of adequate documentation and execution of tests may also be granted at the discretion of the Society.

3 Insulation resistance

3.1 Lighting and power circuits

3.1.1 The insulation resistance between all insulated poles (or phases) and earth and, where practicable, between poles (or phases), is to be at least 1 MΩ in ordinary conditions.

The installation may be subdivided to any desired extent and appliances may be disconnected if initial tests give results less than that indicated above.

3.2 Internal communication circuits

3.2.1 Circuits operating at a voltage of 50 V and above are to have an insulation resistance between conductors and between each conductor and earth of at least 1 MΩ.

3.2.2 Circuits operating at voltages below 50 V are to have an insulation resistance between conductors and between each conductor and earth of at least 0,33 MΩ.

3.2.3 If necessary, any or all appliances connected to the circuit may be disconnected while the test is being conducted.

3.3 Switchboards

3.3.1
The insulation resistance between each busbar and earth and between each insulated busbar and the busbar connected to the other poles (or phases) of each main switchboard, emergency switchboard, distribution board, etc. is to be not less than 1 MΩ.

3.3.2 The test is to be performed before the switchboard is put into service with all circuit-breakers and switches open, all fuse-links for pilot lamps, earth fault-indicating lamps, voltmeters, etc. removed and voltage coils temporarily disconnected where otherwise damage may result.

3.4 Generators and motors

3.4.1 The insulation resistance of generators and motors, in normal working condition and with all parts in place, is to be measured and recorded.

3.4.2 The test is to be carried out with the machine hot immediately after running with normal load.

3.4.3 The insulation resistance of generator and motor connection cables, field windings and starters is to be at least 1 MΩ.

4 Earth

4.1 Electrical constructions

4.1.1 Tests are to be carried out, by visual inspection or by means of a tester, to verify that all earth-continuity conductors and earthing leads are connected to the frames of apparatus and to the hull, and that in socket-outlets having earthing contacts, these are connected to earth.

4.2 Metal-sheathed cables, metal pipes or conduits

4.2.1 Tests are to be performed, by visual inspection or by means of a tester, to verify that the metal coverings of cables and associated metal pipes, conduits, trunking and casings are electrically continuous and effectively earthed.

5 Operational tests

5.1 Generating sets and their protective devices

5.1.1 Generating sets are to be run at full rated load to verify that the following are satisfactory:
- electrical characteristics
- commutation (if any)
- lubrication
- ventilation
- noise and vibration level.

5.1.2 Suitable load variations are to be applied to verify the satisfactory operation under steady state and transient conditions (see Sec 4, [2]) of:
- voltage regulators
- speed governors.

5.1.3 Generating sets intended to operate in parallel are to be tested over a range of loading up to full load to verify that the following are satisfactory:
- parallel operation
- sharing of the active load

- sharing of the reactive load (for a.c. generators).

Synchronising devices are also to be tested.

5.1.4 The satisfactory operation of the following protective devices is to be verified:

- overspeed protection
- overcurrent protection (see Note 1)
- load-shedding devices
- any other safety devices.

For sets intended to operate in parallel, the correct operation of the following is also to be verified:

- reverse-power protection for a.c. installations (or reverse-current protection for d.c. installations)
- minimum voltage protection.

Note 1: Simulated tests may be used to carry out this check where appropriate.

5.1.5 The satisfactory operation of the emergency source of power and of the transitional source of power, when required, is to be tested. In particular, the automatic starting and the automatic connection to the emergency switchboard, in case of failure of the main source of electrical power, are to be tested.

5.2 Switchgear

5.2.1 All switchgear is to be loaded and, when found necessary by the attending Surveyor, the operation of overcurrent protective devices is to be verified (see Note 1).

Note 1: The workshop test is generally considered sufficient to ensure that such apparatus will perform as required while in operation.

5.2.2 Short-circuit tests may also be required at the discretion of the Society in order to verify the selectivity characteristics of the installation.

5.3 Consuming devices

5.3.1 Electrical equipment is to be operated under normal service conditions (though not necessarily at full load or simultaneously) to verify that it is suitable and satisfactory for its purpose.

5.3.2 Motors and their starters are to be tested under normal operating conditions to verify that the following are satisfactory:

- power
- operating characteristics
- commutation (if any)
- speed
- direction of rotation
- alignment.

5.3.3 The remote stops foreseen are to be tested.

5.3.4 Lighting fittings, heating appliances etc. are to be tested under operating conditions to verify that they are suitable and satisfactory for their purposes (with particular regard to the operation of emergency lighting).

5.4 Communication systems

5.4.1 Communication systems, order transmitters and mechanical engine-order telegraphs are to be tested to verify their suitability.

5.5 Installations in areas with a risk of explosion

5.5.1 Installations and the relevant safety certification are to be examined to ensure that they are of a type permitted in the various areas and that the integrity of the protection concept has not been impaired.

5.6 Voltage drop

5.6.1 Where it is deemed necessary by the attending Surveyor, the voltage drop is to be measured to verify that the permissible limits are not exceeded (see Sec 3, [9.11.4]).

APPENDIX 1 ALTERNATIVES, RELAXATIONS AND ADDITIONAL CONSIDERATIONS FOR YACHTS OF LESS THAN 500GT

1 General (Sec 1)

1.1 Documentation to be submitted

1.1.1 Yachts of less than 500 GT which have length more than 50 m will be considered on a case-by-case basis

1.1.2 With reference to Sec 1, [2], the "General arrangement plan of the yacht showing location of main items of the electrical system" is not mandatory.

1.2 Definitions

1.2.1 With reference to Sec 1, [3.26] and Table 3, Table 4, Table 5 are not mandatory.

2 General Design Requirements (Section 2)

2.1 Environmental conditions

2.1.1 With reference to Section 2, [1.5] is not mandatory

2.2 Harmonic distortions

2.2.1 With reference to Section 2, [2.2.2] is not mandatory.

2.3 Electromagnetic susceptibility

2.3.1 With reference to Section 2, par. [3], when allowed in accordance with Pt A, Ch 2, App 3 as an alternative Electrical and electronic equipment, radio and communications equipment may be in compliance with IEC 60533 and IEC 60945.

2.4 Construction

2.4.1 With reference to Section 2, [5.1.4] is not mandatory.

3 System Design (Section 3)

3.1 Source of electrical power

3.1.1 With reference to Section 3, [2.2.6], [2.2.7], [2.2.9], [2.3.8] are not mandatory

3.2 Distribution

3.2.1 With reference to Section 3, [3.5], [3.15.10], [3.15.12], [3.16] and [3.17] are not mandatory.

3.2.2 With reference to Sec 3, [3.7.3] as an alternative the period during which the emergency source of electrical power are to supply the listed services can be of 6 hours..

4 Rotating Machines (Section 4)

4.1 General

4.1.1 With reference to Section 4, when allowed according to Pt A, Ch 2, App 3, as an alternative the requirements of IEC Publication 60034 series and IEC Publication 60092-301 are to be applied

4.1.2 With reference to Section 4, when allowed according to Pt A, Ch 2, App 3, as an alternative all machines are to be tested by Manufacturer and a certificate of compliance is to be issued

5 Transformers (Section 5)

5.1 General

5.1.1 With reference to Section 5, when allowed according to Pt A, Ch 2, App 3, as an alternative transformers are to comply with IEC Publication 60092-303.

5.1.2 With reference to Section 5, when allowed according to Pt A, Ch 2, App 3, as an alternative transformers are to be installed in well-ventilated locations.

5.1.3 With reference to Section 5, when allowed according to Pt A, Ch 2, App 3, as an alternative the connections of transformers are to be protected against such mechanical damage, condensation and corrosion as may be reason-ably expected.

5.1.4 With reference to Section 5, when allowed according to Pt A, Ch 2, App 3, as an alternative all transformers are to be tested by Manufacturer and a certificate of compliance is to be issued.

6 Semiconductor Converters (Section 6)

6.1 General

6.1.1 With reference to Section 6, when allowed according to Pt A, Ch 2, App 3, as an alternative

6.1.2 Semiconductor converters are to conform with IEC Publication 60146.

6.1.3 Converters are to be installed so that the circulation of air around them is not impeded and so that the air temperature at their cooling inlet does not exceed the ambient temperature.

6.1.4 Natural air-cooling units are to be designed with sufficient ventilation openings or with sufficient cooling surface to radiate the heat so that totally enclosed equipment will operate within the design temperature limits.

6.1.5 Converters are not to be mounted near sources of heat such as engine exhaust pipes.

6.1.6 All converters are to be tested by Manufacturer and a certificate of compliance is to be issued.

7 Storage Batteries, Chargers, Uninterruptible Power Systems And Fuel Cells (Section 7)

7.1 General

7.1.1 With reference to Section 7, when allowed according to Pt A, Ch 2, App 3, [2.2], [3.6.1], [3.6.2] and Table 1 are not mandatory. Chargers are to be designed and constructed in accordance with an acceptable and relevant national or international standard.

8 Switchgear And Controlgear Assemblies (Section 8)

8.1 General

8.1.1 With reference to Section 8, when allowed according to Pt A Ch 2 App.3, [1.4.5], [1.4.6], [1.7,1], [1.7.2], [1.7.3] are not mandatory..

9 Cables (Section 9)

9.1 General

9.1.1 With reference to Section 9, when allowed according to Pt A, Ch 2, App 3, [1.1.1], what below may be applied

9.1.2 For the acceptance on board of cables the Manufacturer is to issue a statement providing information on the type and characteristics of the cable, and is to document the results of the type tests according to IEC 60092-3 series publications and IEC 60332-1-1, IEC 60332-3-22 (Category A). The type tests according to IEC 60092-3 series publications and IEC 60332-1-1, IEC 60332-3-22 (Category A) are to be surveyed by the Society, otherwise the good results of the type tests is to be documented by means of test reports issued by inde-pendent and recognised laboratories (see Note 1). Note 1: reference is to be made to the Rules for testing, Certification and Acceptance of Marine Materials and Equipment Ch. 5 [3].

9.1.3 With reference to Sec 9, [1.2], [1.3], [1.4], [1.5] and [2] are not mandatory.

10 Miscellaneous (Section 10)

10.1 General

10.1.1 With reference to Sec 10, [1.1] and [1.2], when allowed according to Pt A, Ch 2, App 3, as an alternative what at [10.1.2] may be applied.

10.1.2 Lighting fittings are to be so arranged as to prevent temperature rises which could damage the cables and wiring. Where the tempera-ture of terminals of lighting fittings exceeds the maximum conductor temperature permitted for the supplied cable, special installation arrangements, such as terminal boxes thermally insulated from the light source, are to be provided. Lighting fittings are to be so ar-ranged as to prevent surrounding material from becoming excessively hot. Lighting fittings are to be secured in place such that they cannot be displaced by the motion of the vessel.

10.1.3 With reference to Sec 10, [4] as an alternative what at [10.1.4] may be applied.

10.1.4 Space heaters are to be so installed that clothing, bedding and other flammable material cannot come in con-tact with them in such a manner as to cause risk of fire. To this end, for example, hooks or other devices for hanging garments are not to be fitted above space heaters or, where appropriate, a perforated plate of incombustible material is to be mounted above each heater, slanted to prevent hanging anything on the heater itself. Space heaters are to be so installed that there is no risk of excessive heating of the bulkheads or decks on which or next to which they are mounted. Combustible materials in the vicinity of space heaters are to be protected by suit-able incombustible and thermal- insulating materials. Heating cables and tapes or other heating elements are not to be installed in contact with combustible materials. Where they are installed close to such materials, they are to be separated by means of a non-flammable material.

10.1.5 With reference to Sec.10, [5.2.2] and [5.2.3] are not mandatory.

11 Electric Propulsion Plant (Section 14)

11.1 General

11.1.1 With reference to Section 14, [7] is not mandatory.

12 Testing (Section 15)

12.1 General

12.1.1 With reference to Section 15, when allowed according to Pt A, Ch 2, App 3, [2] is not mandatory.

13 Battery Powered Yachts (Appendix 4)

13.1 General

13.1.1 With reference to Appendix 2, [3.5] the following sentence is not mandatory: "The energy management system is to be type test-ed or type approved according to the tests listed in Ch 3, Sec 6, Tab 1, as far as mandatory (see Note 1)"

13.1.2 With reference to Appendix 4, Table 2, the fire rating for the battery space need not to be more than what required for machinery space of cat. A, for the relevant navigation type and GT, with a minimum of B15.

APPENDIX 2 ALTERNATIVES, RELAXATIONS AND ADDITIONAL CONSIDERATIONS FOR YACHTS OF LESS THAN 24M LLL

1 General

1.1 Application

1.1.1 Publications by the International Electrotechnical Commission (IEC) or other internationally recognised standards referred to in the rules are those currently in force at the date of agreement for yacht classification.

1.1.2 As an alternative to Section 1 to Section 15 and related appendixes, the following standards apply: :

- for direct current system installations which operate at a rated voltage not exceeding 50 V and for single-phase alternating current installations which operate at a rated voltage not exceeding 250 V: ISO 13297;
- for three-phase alternating current systems which operate at a rated voltage not exceeding 500 V: IEC 60092-507.

For systems which operate at rated voltage exceeding the above limits, the applicable standards will be evaluated on a case by case basis.

1.1.3 In addition to the above-mentioned standards, the requirements in [2] apply.

2 Additional requirements

2.1 Protection of generators

2.1.1 Pt C Ch 2, Sec.3 [6.8.1] applies.

2.2 Radio equipment

2.2.1 Radio equipment is to be supplied by means of two circuits, one from the main switchboard and the other from a dedicated accumulator battery suitably located for use in an emergency. If the emergency source of electrical power is an accumulator battery located in close proximity to the radio installation, the Society may accept that the second source of electrical power is taken from the emergency source of electrical power. Note 1: additional to/different requirements may be required by a National Administrations.

2.3 Protection of motors

2.3.1 Pt C Ch 2, Sec.3 [6.10.1] and [6.10.8] applies.

2.4 Emergency stop

2.4.1 An emergency stop is to be provided for all the machinery spaces fans, fuel and lubricating oil pumps and other pumps handling flammable liquids. The controls for the emergency stop are to be located outside of the space where the fan or pump is located.

2.5 Navigation lights

2.5.1 Pt C, Ch 2, Sec 3, [3.13.3] applies.

2.5.2 Single navigation lights or fitted with single lamps may be accepted by The Society.

2.6 Underwater lights

2.6.1 Pt C, Ch 2, Sec 3, [9.5] applies.

2.7 Electric cables

2.7.1 Pt C, Ch 2, Sec 3, [9] applies.

2.8 Battery Powered Yachts

2.8.1 Pt C, Ch 2, App 4, [5.1.3] is not mandatory.

APPENDIX 3 DETAIL OF DOCUMENTATION TO BE SUBMITTED

1 Detail of documentation required for approval

1.1 General

1.1.1

The documentation required for approval in Sec 1, [2.1.1] is to include all the information listed in Tab 1.

1.1.2

Each drawing submitted for examination is to include the following details:

- date,
- index and date of revision,
- number of the drawing,
- title,
- register number,
- signature of the responsible electrical designer.

Note 1: the professional qualifications of the responsible electrical designer are to be submitted upon request.

1.1.3

It is reminded that in addition to the drawings listed in Sec 1, [2.1.2], also the following electrical drawings are to be submitted for approval:

- diagrams of the electric power circuits and the functional diagram of control, monitoring and safe-ty systems including the remote control from the navigating bridge, with indication of the loca-tion of control, monitoring and safety devices of steering gear, as required by Ch 1, Sec 10, Tab 1;
- electrical diagram of fixed fire-extinguishing systems and fire pumps, as required by Ch 4, Sec 1, Tab 2;
- electrical diagram of power control and position indication circuits for fire doors, as required by Ch 4, Sec 2, Tab 1;
- functional diagrams of power and control system of power-operated watertight doors and their status indication, as required by Pt B, Ch 1, App 3.

Table 1 : Information to be included in the drawings submitted for approval

No.	Documents to be submitted (see Sec 1, [2.1.1])	Information	Notes
1	One line diagram of main and emergency power systems (including ac and dc power systems) including lighting systems (see Fig. 1)	The drawing is to include the single line diagram of: • The main switchboard and all the feeders connected to the main switchboard • The emergency switchboard and all feeders connected to the emergency switchboard • Interconnector feeder between main switchboard and emergency switchboard • The main and emergency source of electrical power (i.e. generators or batteries) • Section boards and distribution boards • The motor control centers (MCC) • The main and emergency lighting distribution • Transformers, converters and similar appliance which constitute an essential part of the electrical supply system • Uninterruptible power system units (UPS) when providing an alternative power supply to essential services and/or when providing an alternative power supply or transitional power supply, if any, to the emergency services.	At least the following additional information are to be included in the drawing: • Type of distribution system • Interlocks • Electrical protections of each feeder • Electrical protection of generator and batteries • Measuring instruments • Ratings of machines, transformers, batteries, semiconductor converters, etc.
2	Electrical power balance of main and emergency supply (including transitional source of emergency power, when required) (see Fig 2) (1).	The load balance of the main supply is to include at least the following operating modes: • Navigation • Port • Maneuvering The load balance is to include all the loads (essential and not-essential) supplied during normal operation of the vessel, taking into consideration their utilization factor and the simultaneity factor. The main load balance is to include the expected operating profiles, i.e. the number of generating sets connected to the network in each operating modes. The load balance of the emergency supply is to include all the emergency loads in simultaneously operation, taking into consideration their utilization factor.	The loads should be grouped in relation to the type of service, e.g. engine services, propulsion services, air conditioning services, galley services, accommodation services, lighting, safety services, etc.. Evidence that the emergency source of electrical power is capable of supply the emergency loads for the time as requested by the applicable Standard is to be provided on the drawing.
3	Calculation of short-circuit currents for each installation in which the sum of rated power of the energy sources which may be connected contemporaneously to the network is greater than 500 kVA (kW)	The drawing is to include the short circuit calculation of: • main switchboard, • emergency switchboard • all the section board, distribution board, MCC, including those fed from transformers	The content of the drawing is under Designer responsibility and will not be reviewed by Tasneef; the document will be kept for information only. Short-circuit cur rent calculation is to be performed in accordance with a method recognised by Tasneef, such as that given in IEC Publication 60363.
Note 1: The figures are only for the purpose of illustration of the type of layout of the referred document.			

No.	Documents to be submitted (see Sec 1, [2.1.1])	Information	Notes
4	List of circuits including, for each supply and distribution circuit, data concerning the nominal current, type, length and cross-section of the cables, nominal and setting values of the protective and control devices (see Fig 3) (1).	The drawing is to include at least the following data/information: For main generators: • rated power, rated current and rated frequency; • cross sectional area of cables of feeder connecting generators to the switchboards, type and manufacturer of cables, length and current carrying capacity; • type and manufacturer of circuit breaker and their electrical characteristics (breaking and making capacity, rated current), type and settings of relay (instantaneous setting, short delay setting and long delay setting); • type of protections provided for generators (e.g. reverse power protection, undervoltage protection, etc.). For emergency generators: • rated power, rated current and rated frequency; • cross sectional area of cables of feeder connecting generators to the switchboards, type and manufacturer of cables, length and current carrying capacity; • type and manufacturer of circuit breaker and their electrical characteristics (breaking and making capacity, rated current), type and settings of relay; • type of protections provided for generators (e.g. undervoltage protection, etc.). For main switchboard, emergency switchboards, each section board, each distribution board, motor control centers and UPS and/or battery distribution: • rated voltage and short circuit currents; • for each services (essential and not essential): - rated power and rated current, - type, manufacturer, cross-sectional area, current carrying capacity, voltage drop and length of cables; - type and manufacturer of circuit breaker and their electrical characteristics (breaking and making capacity, rated current) and type and settings of relay; - emergency shutdown, if provided; - connection to the load shedding device (or to other equivalent arrangements).	Fire detection system: diagram, location and cabling
Note 1: The figures are only for the purpose of illustration of the type of layout of the referred document.			

No.	Documents to be submitted (see Sec 1, [2.1.1])	Information	Notes
5	Single line diagram and detailed functional diagram of the main switchboard.	The drawing of the single line diagram of the main switchboard is to include at least: • front view of the switchboard • bus-bars dimension • electrical protection of each feeder • indicating and control instruments • details of services supplied • type of electrical protection provided for the main generators • degree of protection. The functional diagram is to be a detailed two-wire, three-wire or four-wire diagram, as applicable, and is to include: • measuring circuit and instruments (voltmeters, insulation monitoring devices, ammeter, etc.) • indicating and control circuits • protective devices (e.g. reverse power protection, undervoltage protection, etc.) of main generators • load shedding device • details of interlocks (e.g. interlocks of circuit breakers of the main generators with circuit breaker of shore connection, etc. • list of components.	The functional diagram is necessary to check the operation of a switchboard which include switchgear and controlgear assembly with associated control, measuring, signalling, protective, regulating equipment with all the internal electrical and mechanical interconnections. A functional description of operation of the main switchboard in all operational modes should be submitted for information to support the approval of the functional diagram of the switchboard.
Note 1: The figures are only for the purpose of illustration of the type of layout of the referred document.			

No.	Documents to be submitted (see Sec 1, [2.1.1])	Information	Notes
6	Single line diagram and detailed diagram functional of the emergency switchboard.	The drawing of the single line diagram of the emergency switchboard is to include at least: • front view of the switchboard • bus-bars dimension • electrical protection of each feeder • indicating and control instruments • details of services supplied • type of electrical protection provided for emergency source of power (batteries or generators) • degree of protection. Where the emergency source of electrical power is a generator, the functional diagram is to be a detailed two-wire, three-wire or four-wire diagram, as applicable, and is to include: • measuring circuit and instruments (voltmeters, insulation monitoring devices, ammeter, etc.) • indicating and control circuits • protective devices of emergency source of power • preferential tripping device, if any • detail of interlocks (e.g. interlocks of circuit breaker of the emergency generator with circuit breaker of feeder connecting main and emergency switchboard, interlock of circuit breaker of the emergency generator with circuit breaker of shore connection, where connected to the emergency switchboard, etc.) • auxiliary circuits diagram and relevant power supplies • operational modes (manual and automatic, if required by the Rules) • list of components including type and manufacturer.	The functional diagram is necessary to check the operation of a switchboard which include switchgear and controlgear assembly with associated control, measuring, signalling, protective, regulating equipment with all the internal electrical and mechanical interconnections. A functional description of operation of the emergency switchboard in all operational modes: e.g. manual, automatic (if required by the Rules) should be submitted for information as a support for the approval of the functional diagram of the emergency switchboard
7	Diagram of the most important section boards and motor control centers above 100 A.	The drawing of the motor control centers is to include: • single line diagram • detailed three wire functional diagram of each starter, including power, control and signaling circuits (see Fig 4) (1) • detail of auxiliary power supplies (i.e. if they are taken from the power circuit or by an external power supplies) • list of components • front view.	It is intended that also the drawing of the distribution boards and single starters having nominal current greater than 100 A are to be submitted for approval.
Note 1: The figures are only for the purpose of illustration of the type of layout of the referred document.			

No.	Documents to be submitted (see Sec 1, [2.1.1])	Information	Notes
8	Detailed diagram of the navigation-light switchboard (see Fig. 5) (1)	The drawing is to be a three-wire functional diagram of the distribution board specially reserved for the navigation lights and is to include: • power supplies • the change-over switch, as requested by the Rules • the electrical protection of each navigation light (circuit breakers or double-pole switch and a fuse) • audible and/or visual warning provided in case of failure of the navigation light	Type, number and characteristics of navigation lights is not to be included in the present drawing.
9	For electrical propulsion installations: . • single line diagram, •control system and its power supply diagram, •alarm and monitoring system including list of alarms and monitoring points and its power supply diagram, • safety system including the list of monitored parameters and its power supply diagram	The single line diagram is to include: • ratings of electrical machines, transformers, batteries, harmonic filters, converters, etc. • size and current loadings of cables • type and rating of circuit-breakers and fuses • details of instrumentation and protective devices • wiring diagram of power supplies of auxiliary circuits.	
Note 1: The figures are only for the purpose of illustration of the type of layout of the referred document.			

Figure 1

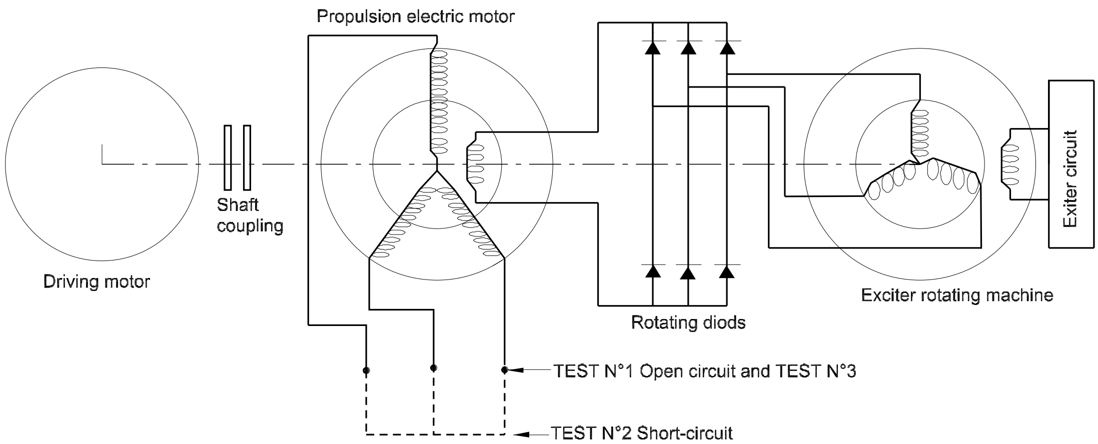


Figure 2

Drawing n. ... Rev. ... RI ...	ELECTRICAL LOAD ANALYSIS															
SERVICES																
Item n.	DESCRIPTION	UNIT n.	POWER RATING (kW)	POWER ABSORB (kW)	PORT			MANEUVERING			NAVIGATION			EMERGENCY		
					N.	%	P [KW]	N.	%	P [KW]	N.	%	P [KW]	N.	%	P [KW]
	PROPULSION SERVICES															
1																
2																
...																
	LIGHTING SERVICES															
1																
2																
3																
...																
	...															
...																

ELECTRICAL LOAD ANALYSIS - SUMMARY TABLE					
		PORT	MANEUVERING	NAVIGATION	EMERGENCY
		POWER KW	POWER KW	POWER KW	POWER KW
PROPULSION SERVICES		...	...	...	...
LIGHTING SERVICES		...	...	...	...
...					
...					
...					
...					
TOTAL POWER REQUIRED		...	...	...	...
GENERATOR RUNNING	DG1	... kW ... %	... kW ... %	... kW ... %	
	DG2	... kW ... %	... kW ... %	... kW ... %	
	...	... kW ... %	... kW ... %	... kW ... %	
	EDG				... kW ... %

Figure 3

Sheet n. ...		RI		
DRAWING n. ...	REV. ...	SHORT CIRCUIT CURRENTS SYMMETRICAL ... KA PEAK ... KA		VOLTAGE ... V FREQUENCY ... Hz
SERVICE				
CIRCUIT		CABLE	CIRCUIT BREAKER	CONTROLS

ITEM	DESCRIPTION			CABLE					CIRCUIT BREAKER				RELAYS				CONTROLS			
		POWER	RATED CURRENT	TYPE	CROSS SECTIONAL AREA	CURRENT CARRYING CAPACITY	LENGTH	VOLTAGE DROP	TYPE	RATING	BREAKING CAPACITY	MAKING CAPACITY	TYPE	SHORT CIRCUIT PROTECTION SETTING	SHORT CIRCUIT PROTECTION DELAY	OVERLOAD PROTECTION SETTING	EMERGENCY SHUTDOWN	PREFERENTIAL TRIPPING	UNDERVOLTAGE COIL	:
		KW	A		N x mmq	A	m	V		A	KA	KA		A	s	A				
CIRC. N. ...	....																			
CIRC. N. ..	....																			
CIRC. N. ...	....																			

Figure 4

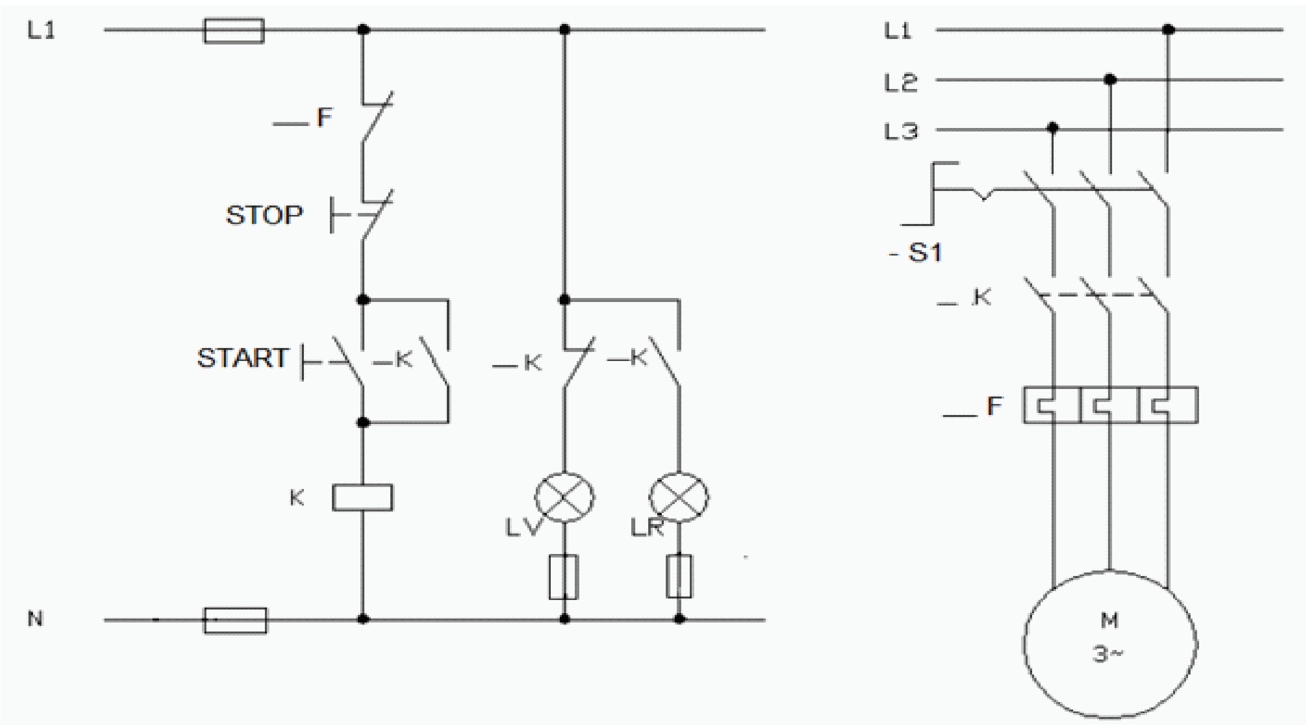
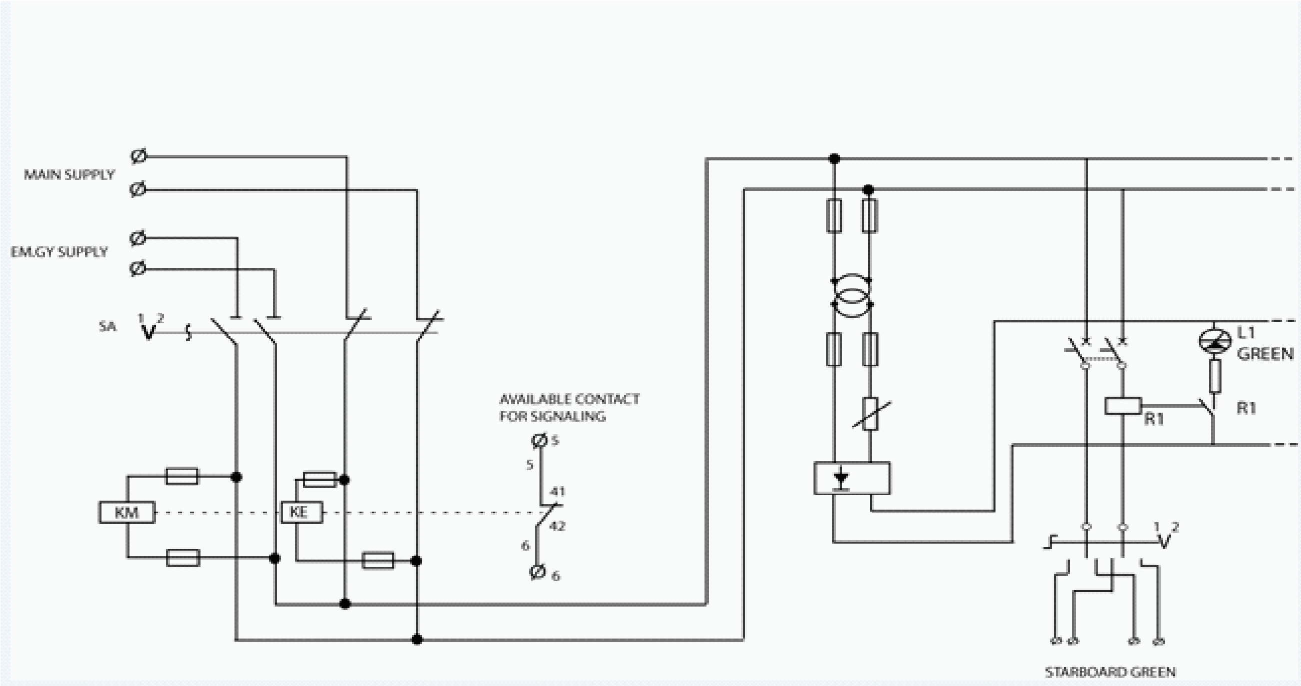


Figure 5


MAIN SUPPLY
EM.GY SUPPLY
SA
1 2
AVAILABLE CONTACT
FOR SIGNALING
5
41
42
6
KM
KE
L1
GREEN
R1
R1
1 2
STARBOARD GREEN

APPENDIX 4 BATTERY POWERED YACHTS

1 General

1.1 Application

1.1.1

The provisions of this Appendix apply to yachts where batteries, other than Lead and Nickel-Cadmium and Nickel-Metal-Hydride batteries, are installed to supply essential or not-essential services and emergency services, except batteries embedded in consumer products like computers and similar appliances, otherwise stated by Flag Administration.

1.1.2

The requirements in this Appendix are applicable to installations with a variety of lithium battery chemistry; since the battery technology is under development, additional requirements may be required by the Society on a case by case basis.

1.1.3

The Society may consider different arrangements than those stated in this Appendix, provided that they ensure an equivalent level of safety, to be demonstrated by appropriate risk analysis techniques.

1.2 Definitions

1.2.1

The following definitions and abbreviations are additional to those given in the other Parts of the Rules:

- Battery Management System (BMS): an electronic system that controls and monitors the state of the batteries by protecting the batteries from operating outside its safe operating area.
- Energy Management System (EMS): a system providing monitoring and control of the energy.
- Cell: an individual electrochemical unit of a battery consisting of electrodes, separators, electrolyte, container and terminals.
- Battery: assembly of cells ready for use as storage of electrical energy characterized by its voltage, size terminal arrangement, capacity and rate capability.
- Battery space: compartments (rooms, lockers or boxes) used primarily for accommodation of batteries .
- Battery system: the battery installation including battery banks, electrical interconnections, BMS and other safety features.
- Module: group of cells connected together either in a series and/or parallel configuration.
- State of Charge (SOC): state of charge expressed as a percentage of the rated capacity giving an indication of the energy available from the battery.
- State of Health (SOH): general condition of a battery, including its ability to deliver the specified performance compared with a new battery.
- Venting: release of excessive internal pressure from a cell/battery in a manner intended by design to preclude rupture or explosion.
- Explosion: failure that occurs when a cell container or battery case opens violently and major components are forcibly expelled.
- Fire: the emission of flames from a cell or battery.
- Upper limit of the charging voltage: the highest allowable charging voltage as specified by the cell Manufacturer.

1.3 Documentation to be submitted

1.3.1

In addition to the documents required in Sec 1, for battery powered yachts the plans and documents listed in Tab 1 are to be submitted.

The Society reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the systems and components.

2 System design

2.1 General

2.1.1

Battery installations is regarded as generating set of the main source of electrical power on condition that the capacity of the battery installation is sufficient for the intended operation of the yacht and such design capacity is stated in the class certificate as an operational limitation.

2.1.2

In yachts or units where the main source of electrical power is based on battery installations only, the battery installation is to be divided into at least two independent battery systems located in two separate battery spaces, each having a capacity sufficient for the intended operation of the yacht.

Table 1 : Documentation to be submitted

No.	A/I **(1)**	Document
1	A	Block diagram and electrical wiring diagram of the battery system and system interfaced to the battery system, including control, monitoring and alarm system, emergency shutdown, PMS, etc.
2	I	Technical specification of the batteries, including technical data (electrical characteristics like voltage and capacity, discharge and recharge rates), battery chemistry and functional description of cell/battery system including at least cell/batteries configuration, safety devices (BMS), interfaces to monitoring/safety, diagnostic, including the list of controlled and monitored parameters.
3	I	Functional description of the energy management system (EMS), when required (see [2.1.3].
4	A	A risk assessment addressing all potential hazards represented by the type (chemistry) of batteries, the evaluation of the risk factors and measures to control and reduce the identified risks. Note: for the Risk Assessment reference is to be made to Tasneef "Guide for Risk Analysis".
5	A	Test program Note: the test program is to include the functional tests as per [5.2] (alarm system, safety system, control system, etc.) [5] and further tests, if any, resulting from the Risk Assessment for the specific battery system.
6	A	Electrical load balance capable of reflecting the operational mode stated in the battery system operating philosophy (maximum designed deterioration rate is to be included).
7	A	A general arrangement plan of battery installation including the indication of structural fire protection and the safety systems **(2) (3)**.
8	I	Battery Manufacturer's instructions on active fire extinguishing system and confirmation about suitability of the proposed extinguishing agent for the specific type of batteries.
9	I	Statement of conformity of the batteries to IEC 62619, IEC 62620, IEC 60529 or UN38.3, when requested by the Rules.
10	I	Copy of type approval certificate of the battery systems, when requested by the Rules
11	I	An overall description of the battery system operating philosophy for each operational mode (including charging).
12	I	Operation and maintenance manuals including instructions for the safe connection/disconnection of batteries (see [5.4]).
13	A	Hazardous area classification (if applicable to the specific battery chemistry) and list of certified safety type electrical equipment installed in hazardous areas (as applicable).
14	I	Test Report of battery system at cellular, modular and system level in order to identify the damage potential of a possible thermal runaway event (Propagation Test) including gas analysis and explosion analysis as appli-cable and depending on the safety concept adopted.
15	I	Battery system maker statement confirming suitability of the selected fire extinguishing system and ventila-tion arrangement for the specific project.

(1) A: to be submitted for approval I: to be submitted for information
(2) Where a battery space is provided, based on the Risk Assessment (see [4.2]), evidence of the solution adopted for the battery space is to be given in the yacht's active (detection and fighting) and passive fire protection, gas detection system and ventilation system drawings.
(3) The plan has to show:
- the battery pack arrangement with respect to the space it is being installed in
- the clearance distances between the other ancillary equipment in the space and the battery pack.

2.1.3

When batteries are used as storage of power for the propulsion or dynamic positioning system or as part of the main source of electrical power, an Energy Management System (EMS) according to [3.5] is to be provided.

2.1.4

Where the batteries are used for propulsion and steering of the yacht, the system is to be so arranged that the electrical supply to equipment necessary for propulsion and steering will be maintained or immediately restored in the case of battery system failure.

2.1.5

Cables connecting each battery system to the main switchboard are to be arranged as per Sec 11, [5.2].

2.1.6

A Risk Assessment, to be initiated in the design phase, is to be carried out to cover, but not limited to:

- evaluation of the risk factors,
- measures to control and reduce the identified risk, including potential gas development (e.g. toxic, corrosive), fire and explosion risk and
- action to be implemented.

The outcome of the assessment will give the additional measures to be adopted for minimizing the risks related to the use of batteries and among such measures, if the battery system needs to be installed in a space assigned to batteries only.

2.1.7

The risk assessment has:

- to identify risks due to external heating, fire or flooding
- to identify any fault in the battery system that may cause malfunction to essential services including but not limited to propulsion and steering or to emergency services and measures to mitigate the related risk,
- to evaluate any risk related to the location of batteries in the same spacewith other system supporting essential or emergency services, including pipes and electrical cables, distribution switchboards and so on, including but not limited to thermal runaway of the battery system, external and internal short-circuit,
- to evaluate any risk related to the location, in the same space, of batteries and other systems related to non essential services,
- to address sensor failures (e.g. temperature measurement sensor failure, individual cell voltage measurement sensor failure) and alarm, control and safety system failures (e.g. BMS and EMS failures including power and communication failures),
- to assess the selected fire extinguishing and ventilation arrangement according to battery system maker guidelines considering the specific design features of the .

2.1.8

Battery cells of different physical characteristics, chemistries and electrical parameters are not to be used in the same electrical circuit.

2.1.9

The batteries are to be properly located (see [4]) and, where necessary, insulated to prevent overheating of the system.

2.1.10

The minimum required degree of protection is to be, in relation to place of installation of the battery system, according to Sec 3, [4]. Where water-based fire extinguishing system is used in the battery space, IP 44 is required as a minimum (see Note 1 and Note 2).

Note 1: if other fire-extinguish systems are used, the minimum IP can be reduced as result of the risk assessment.

Note 2: where the risk assessment identifies risks from water immersion (e.g. when batteries are installed below the freeboard deck), the batteries are to have a minimum degree of protection IP X7.

2.2 Constructional requirements

2.2.1

Battery enclosure covering modules and cells are to be made of flame retardant materials.

2.2.2

Each cell or battery case is to incorporate a pressure relief mechanism or is to be constructed in such a way to relieve excessive internal pressure at a value and rate that will be precluded rupture, explosion and self-ignition.

2.2.3

A thermal protection device, capable to disconnect the battery in case of high temperature, is to be provided in the battery.

2.2.4

The design and construction of battery modules have to reduce the risk of a thermal propagation due to a cell thermal runaway, maintaining it confined at the lowest possible level (e.g. confined within a module). This may be achieved by means of partition plates or sufficient distance in accordance with maker recommendation to prevent escalation between battery modules in case of a thermal runaway.

2.2.5

Terminals are to have clear polarity marking on the external surface of the battery. The size and shape of the terminal contacts are to ensure that they can carry the maximum cur- rent. External terminal contact surfaces are to be made of conductive materials with good mechanical strength and corrosion resistance. Terminal contacts are to be arranged so as to minimize the risk of short circuits.

2.2.6

The battery system is to be provided with a Battery Management System (BMS) according to [3.2].

2.3 Electrical protection

2.3.1

The outgoing circuits of the battery system are to be protected against overload and short-circuit by means of fuses or multi- pole circuit breakers having isolating capabilities.

2.3.2

An emergency shutdown system is to be installed and capable of disconnecting the battery system in an emergency.

2.3.3

The battery system is to have means for isolating purpose for maintenance purposes. This isolating device is to be independent of the emergency shutdown arrangement.

2.4 Battery charger

2.4.1

Battery chargers are to comply with the requirements of Sec 7.

2.4.2

The battery charger is to be designed to operate without exceeding the limits given by the battery system Manufacturer (e.g. current and voltage level).

2.4.3

The battery charger is to be interfaced with and controlled by the BMS.

2.4.4

Any detectable failure in the battery charger, including charging/discharging failure, is to give an alarm in a continuously manned control position.

3 Control, monitoring, alarm and safety systems

3.1 General

3.1.1

For the purpose of these rules, unless differently state in the text, a required alarm is to be intended as an audible and visual alarm and is to be given in a continuously manned control position.

3.1.2

Control, monitoring, alarm and safety systems are to comply with the requirements of Chapter 3 and are to be type approved or type tested according to Ch 3, Sec 6.

3.2 Battery management systems (BMS)

3.2.1

The BMS and related monitoring and safety systems (see [3.4]) are to have self-check facilities.

In the event of a failure, an alarm is to be activated.

3.2.2

The BMS is to be continuously powered so that a single failure of the power supply system does not cause any degradation of the BMS functionality; an alarm is to be given in the event of failure of any of the power supplies.

Unless the power supply is derived from different strings of batteries, one of the power supplies is to be derived from the emergency source of electrical power.

Where each battery is fitted with a BMS card, the individual cards may have a single power supply from the relevant battery.

An alarm is to be given and safety action taken in the event of loss of all the power supplies.

3.2.3

The battery management system (BMS) is to:

- provide limits for charging and discharging of the battery,
- protect against over-current, over-voltage and under-voltage by disconnection of the battery system,
- protect against over-temperature by disconnection of the battery system,
- provide cell and module balancing.

3.2.4

The following parameters are to be continuously monitored and indications are to be provided at a local control panel and in a continuously manned control position for:

- system voltage,
- max, min, average cell voltage,
- max, min and average cell or module temperature,
- battery string current.

3.2.5

When battery system is used as storage of power for the propulsion system or as part of the main source of electrical power, State of Charge (SOC) and State of Health (SOH) of the batteries are to be displayed at a continuously manned control station.

3.3 Alarm system

3.3.1

Abnormal conditions which can develop into safety hazards are to be alarmed before reaching the hazardous level.

3.3.2

Any abnormal condition in the battery system is to initiate an alarm.

3.3.3

At least the following conditions or events have to initiate an alarm at a local control panel and in a continuously manned control position:

- safety intervention of the BMS of the battery system,
- high ambient temperature,
- failure of cooling system or leakage of liquid cooling system,
- low ventilation flow inside the battery room,
- overvoltage and undervoltage,
- cell voltage unbalance,
- high cell temperature,
- other safety protection functions.

Other possible abnormal conditions are to be considered on the basis of the outcome of the Risk Assessment (see [2.1.7]) and relevant mitigating measures are to be adopted.

3.3.4

When batteries are used as storage of power for the propulsion or dynamic positioning systems or as part of the main source of electrical power, an alarm is to be given on the bridge when State of Charge (SOC) reaches minimum required capacity for yacht intended operations.

3.4 Safety system

3.4.1

The safety systems are to be:

- designed so as to limit the consequence of internal failures (e.g. failure in the safety system is not to cause shut down of battery system)
- self-monitoring,
- capable of acting on the controlled system following the fail-to safety principle,
- capable of detecting sensor malfunctions.

3.4.2

The safety systems are to be activated automatically in the event of identified conditions which could lead to damage of the battery system. Activation of any automatic safety actions is to activate an alarm. Manual override of safety functions is not to be possible.

3.4.3

Voltage of any one of the single cells is not to exceed the upper limit of the charging voltage as specified by the cell Manufacturer. The battery charger is to be stopped when the upper limit of the charging voltage is exceeded for any one of the single cells.

3.4.4

An emergency shutdown (ESD) system is to be arranged as a separated hardwired circuit and it is to be independent from the control system.

3.4.5

Activation means of the ESD are to be provided locally, from outside the battery space, and from a continuously manned control station.

3.4.6

When battery installation is used as storage of power for the propulsion or dynamic positioning systems or as part of the main source of electrical power, the emergency shutdown is also to be located on the bridge.

3.4.7

When battery installation is used as storage of power for the propulsion or DP systems or as part of the main source of electrical power, in case of over temperature in the battery system, an alarm and a request of manual load reduction is to be given on the bridge at a temperature lower than the one causing intervention of the BMS. As an alternative an automatic load reduction system may be provided. Its intervention is to generate an alarm.

3.4.8

Other possible abnormal conditions, which could lead to damage or additional hazards to battery system, are to be considered on the basis of the outcome of the Risk Assessment.

3.4.9

Sensors are to be designed to withstand the local environment.

3.4.10

The enclosure of the sensor and the cable entry are to be appropriate to the space in which they are located.

3.4.11

Cables to be operable under fire conditions (e.g. where required as result of the Risk Assessment), are to be of a fire-resistant type complying with IEC Publication 60331 series.

3.5 Energy Management system

3.5.1

When required per [2.1.3], an energy management system (EMS) is to be provided complying with the requirements of Chapter 3 consisting of several levels of controls and alarm functions, such as:

- monitoring and alarm functions of all power sources, inverters and disconnectors;
- voltage and power control for DC distribution system;
- available power and charge/discharge status of the storage energy source;

- interface with Power Management System (PMS) for combinations of AC and DC distribution systems;
- inverter control for the overall system.

The energy management system (EMS) is to be independent from the battery management system (BMS) for lithium batteries, however EMS may be integrated in the PMS.

The EMS is to be continuously supplied by uninterruptible power supply systems (UPS) and a failure is to initiate an alarm in a manned location.

The energy management system is to be type tested or type approved according to the tests listed in Ch 3, Sec 6, Tab 1, as far as applicable (see Note 1).

Note 1: If the energy management functionality is implemented in another system, e.g. as part of the power management system (PMS), then the systems are to be certified together.

3.5.2

The EMS is to be capable to provide at least the following information on the bridge:

- energy available from batteries (SOC),
- power available from batteries,
- time or range for which the battery can provide energy according to actual operational conditions,
- alarm for minimum capacity reached,
- battery state of health (SOH).

4 Location

4.1 General

4.1.1

Batteries are to be arranged aft of collision bulkhead and in such a way that danger to persons and damage to vessel due to failure of the batteries (e.g. caused by gassing, explosion, and fire) is minimized.

4.1.2

Batteries are not to be located in a battery box on the open deck exposed to sun and frost.

They are to be located where they are not exposed to excessive heat, extreme cold, spray, steam, shocks or vibration or other conditions which would impair their safety, performance or accelerate deterioration.

4.1.3

Batteries are to be located in such a way that the ambient temperature remains within the Manufacturer's specification at all times.

4.1.4

Batteries are to be suitably housed by means of compartments (rooms, lockers or boxes) which are to be properly constructed and efficiently ventilated and cooled (as necessary) in such a way to keep the battery system at a specified set of environmental conditions.Depending on installation Risk Assessment that shall be issued this requirement can be partially waived .

4.1.5

Battery system is to be arranged following the Manufacturer's prescriptions in particular to prevent cascade effects in case of a thermal runaway (e.g. partition plates or distance in accordance with Manufacturer's recommendations).

4.1.6

Batteries are to be located in a battery space placed outside the machinery space within the extreme borders of the main machinery space of Category A, spaces containing main or emergency source of electrical power, associated transforming equipment if any, or other high fire risk spaces containing stowed flammable liquid and preferably not adjacent to them. Exceptions will be evaluated on a Risk Assessment basis.

4.1.7

When the main source of electrical power is based on battery installations only, one of the two battery systems required in [2.1.2] is to be placed in a battery space located in the same machinery space of the main switchboard.

4.1.8

Depending on the battery chemistry, it may be necessary to define a hazardous area for the installation of appropriate equipment (see Tab 1 No. 6).

4.2 Battery space

4.2.1

When required, based on [4.1.4] or the Risk Assessment (see [2.1.6]), a space assigned to batteries only is to be foreseen.

4.2.2

Access to this space is to be through self-closing doors. As an alternative normally closed doors with alarm may be considered.

4.2.3

External hazards, such as fire and water ingress are to be taken into account in the Risk Assessment, in order to assess the risk associated with an external event (e.g. a fire spreading from adjacent rooms to the battery space, water flooding and so on) and possible countermeasures (e.g. suitable segregation of the battery space).

No heat sources or high fire risk equipment are to be located in battery spaces.

4.2.4

A fire detection system and a fixed fire extinguishing system appropriate to the battery chemistry are to be provided in the battery space.

The type is to be chosen following the battery Manufacturer's instructions.

Examples of fire extinguishing systems may be a powder or a gas based or water-based fixed fire extinguishing system provided that the suitability of the extinguishing agent for the specific type of batteries is confirmed by the battery Manufacturer.

Automatic release is only acceptable for small, not accessible, battery spaces.

Where an automatic release of fire extinguishing media is accepted, its activation is to be confirmed by more than one sensor.

4.2.5

The battery spaces are to be fitted with a forced ventilation system of extraction type, which is to be:

- independent from any other ventilation system serving other spaces,
- provided with local manual stop, still available in case of failure of the automatic and or remote control system,
- provided with indication of ventilation running and of battery space ambient temperature,
- with a capacity (rate) according to battery manufacturer guidelines on the basis of the gas release identified in the gas analysis or propagation test,
- fitted with inlet from open air,
- fitted with exhaust outlet to open air far from accommodation and machinery ventilation inlets,
- fitted with non-sparking fans driven by a certified safe type electric motor in case the ventilation duct is considered to contain ex-plosive atmosphere in case of thermal runaway.

4.2.6

Appropriate means to maintain the battery working temperature within the Manufacturer's declared limits are to be provided (e.g. by means of liquid cooled solutions or ventilation systems provided with control of air temperature).

4.2.7

Battery modules with liquid cooling are to be designed such that the risk of a cooling liquid leakage inside the module is minimized.

The cooling system is to include at least two pumps for each primary and secondary circuits: one main and one standby. The standby pump can be omitted only if the consequences of main pump failure are addressed in the risk assessment [2.1.7].

4.2.8

In case of liquid cooled solutions, a ventilation system is anyway required to extract possible gases or vapours in consequence of a battery abnormal condition.

4.2.9

Depending on the battery chemistry, a gas detection system, for the gases that may be emitted from the battery system in the event of a serious fault, may be requested as an outcome of the risk assessment.

In this case,

- an alarm at 30% of LEL and automatic disconnection of batteries are to be provided,
- an alarm at 60% of LEL and automatic disconnection of all electrical equipment non certified of safety type for the specific hazardous area, gas, vapour are to be provided.

A failure in the gas detection system is to be alarmed but is not to cause above mentioned automatic disconnections.

4.2.10

Depending on the battery chemistry, appropriate ventilation to prevent the formation of explosive atmospheres in the battery space (e.g. to limit the concentration of flammable gasses and thereby reduce the risk for fire) is to be provided.

At this purpose the highest rate of gas emissions is to be considered.

4.2.11

Depending on the battery chemistry, when a hazardous area is to be considered, mechanical exhaust non-sparking fan driven by a certified safe type electric motor, and inlet from open air are to be arranged.

4.2.12

Battery spaces are to be insulated in way of other spaces as indicated in Tab 2.

4.2.13

Battery spaces are to be considered as spaces not normally manned.

4.2.14

The battery space is not to contain other systems supporting essential or emergency services, including piping and electric cables serving such systems, in order to prevent their loss upon possible failures (e.g. thermal runaway) in the battery system.

Table 2

Bulk-head	Control Station 1	Corridor 2	Accom-moda-tion spaces 3	Stair-ways 4	Service spaces (low risk) 5	Machinery Space of cat A 6	Machinery Space 7	Service spaces (high risk) 8	Open deck 9	Garages 10	Muster stations
Li Battery Space	A60	A15	A30	A15	A0	A60	A0	A30	A0	A60	A60
Li Battery Space Below	A60	A60	A30	A60	A0	A60	A0	A30	A0	A60	A60
Li Battery Space Above	A0	A0	A0	A0	A0	A60	A0	A0	A0	A60	A60

5 Testing

5.1 General

5.1.1

Battery systems are to be tested by the Manufacturer.

5.1.2

Batteries are to be subjected to functional and safety tests according to IEC Publication 62619 and 62620 , or UN 38.3 or in accordance with other equivalent national or international standards.

5.1.3

When the aggregate capacity of a battery system exceeds the rating of 20 kWh, the battery system is to be of a type approved in accordance with the Society "Rules for the type approval certification of lithium battery systems".

5.2 Testing and inspection at Manufacturer premises

5.2.1

Battery systems are to be tested by the Manufacturer according to a test program proposed by the Manufacturer and approved by the Society and which is to include at least functional tests of battery system/BMS and control, monitoring and safety systems and further tests, if any, resulting from the Risk Assessment.

Table 3

No.	Test/inspection
1	Examination of the technical documentation, as appropriate, and visual inspection
2	Functional test of the BMS, including safety functions and applicable alarms listed in [3.3.3]
3	Dielectrical strength (high voltage test) **(1)**
4	Insulation resistance test **(1)**
5	Sensor failure test (e.g. power supply failure, disconnection, short circuit, etc.)
6	Emergency shutdown (ESD) functional test
7	Communication failure between BMS and battery charger
8	Testing of the cooling system when submitted to acceptance testing together with the battery system
9	Check of test certificate for prescribed degree of protection
(1) Refer to Sec 8, [3.3] and Sec 8, [3.4]. In order to prevent damages to the electronic components of the battery system, the electronic components can be disconnected during the high voltage test.	

5.3 Testing and inspection after installation on board

5.3.1

After installation, and after any important repair or alteration which may affect the safety of the arrangement, following a check of compliance with the plans, the battery system is to be subjected to tests and inspections, to the satisfaction of the Surveyor in charge.

5.3.2

Performance tests are to be carried out on the battery system; the test program is to include functional tests as per Tab 4 and further tests, if any, resulting from the Risk Assessment.

5.4 Plans to be kept on board

5.4.1

An operation manual is to be kept on board which includes at least:

- charging procedure,
- normal operation procedures, including instructions for the safe connection/disconnection of batteries,
- emergency operation procedures,
- estimated battery deterioration (ageing) rate curves, considering modes of operation.

5.4.2

A maintenance manual for systematic maintenance and functional testing is to be kept on board which includes at least:

- tests on all the equipment affecting the battery system (e.g. instrumentation, sensors, etc.),
- recommended test intervals to reduce the probability of failure,
- recommended survey plan (annual and renewal surveys),
- functional tests of control, monitoring, safety and alarm system,
- verification of the State of Health (SOH),
- instructions for Software Maintenance.

Table 4

No.	Test/verification
1	Insulation resistance test as per Sec 15, [3.3]
2	Test of the functionality of the battery system and BMS and its auxiliaries, including alarms, and safety functions, emergency stop, including simulation of changes in parameters and simulation of sensor failure and of communica-tion failure (e.g. with battery charger)
3	Test of the functionality of the auxiliary services in the battery space (e.g. ventilation, liquid cooling, gas detection, fire detection, leakage detection)
4	Verification of proper calculation and indication of SOC and SOH (when required per [3.2.4]) **(1)**
5	Verification of correct regulation of charging and discharging currents
6	Verification of the functionality of the EMS (when required per [2.1.3])
7	Test of the independent disconnecting device as per [2.3.3]
(1) Tests for the verification of the battery SOH are to be carried out (e.g. complete charge/discharge cycle or other methods as per Manufacturer's indications).	

APPENDIX 5 FUEL CELL POWERED YACHTS

1 General

1.1 Scope

1.1.1 Application

The provisions of this Appendix apply to the arrangement, installation, control, monitoring and safety systems of yachts using fuel cell power installations. These Rules are applicable to installations with several different configurations of fuel cell power installations. Since the fuel cell is a novel technology under continuous development, additional requirements to those specified in these Rules may be required by Tasneef on a case-by-case basis depending on the design principles of the fuel cell in subject. Where the fuel cell power installations consist of the fuel cell power systems which are enclosed in modules, the Tasneef "Rules for the Type Approval of Fuel Cell Power Modules" apply in conjunction with this Appendix.

1.1.2 Acceptance by the flag Administration

The use of fuel cells on yachts requires acceptance by the Administration of the State whose flag the yacht is entitled to fly.

1.1.3 MSC.1/Circ.1647 requirements and the Society's rules

For fuel cell powered yachts, the requirements of the IMO Interim Guidelines for the Safety of s using Fuel Cell Power Installations set out in the annex of IMO circular MSC.1/Circ.1647 (hereinafter named "MSC.1/Circ.1647") are to be applied as class requirements as specified and with the deviations given in this Appendix.

For the scope of classification, when reference is made to paragraphs of MSC.1/Circ.1647 where the wording "Administration" is used, it is to be regarded as referring to the "Society".

In general, this Appendix applies to fuel cell power installations and to their interfaces with the other systems. Unless otherwise specified, the machinery, equipment and systems of fuel cell powered yachts are also to comply with the requirements given in Part C.

The fuel cell power installations designed to use low-flashpoints fuels as primary fuel (e.g. LNG, LPG, NH_3, methyl/ethyl alcohol, hydrogen) are additionally to comply with the requirements set in the rules recalled in Ch.1 Sec.4, as applicable.

The electrical equipment needed for the conditioning of the electrical output from the fuel cell power installation such as e-filters, inverters, converters and transformers are to comply with Sec 5 and Sec 6. The reforming equipment as well auxiliary systems are to comply with Ch 1, Sec 3 and Ch 1, Sec 10.

1.1.4 MSC.1/Circ.1647 requirements not within the scope of classification

The following requirements of MSC.1/Circ.1647 are not within the scope of classification:

- Section 3 - Fire Safety

These requirements are applied by the Society when acting on behalf of the flag Administration, within the scope of delegation (see [1.1.6]).

1.1.5 Correspondence of the MSC.1/Circ.1647 with the Rules

All the requirements of this Appendix are cross referenced to the applicable paragraphs of MSC.1/Circ.1647, as appropriate.

1.1.6 Statutory certificates

The responsibility for interpretation of the MSC.1/Circ.1647 requirements for the purpose of issuing statutory certificates for fuel cell powered s lies with the Administration of the State whose flag the yacht is entitled to fly.

Whenever the Society is authorized by an Administration to issue on its behalf the statutory certificates for fuel cell powered s, or where the Society is authorized to carry out investigations and surveys on behalf of an Administration on the basis of which the statutory certificates for fuel cell powered s will be issued by the Administration, or where the Society is requested to certify compliance with MSC.1/Circ.1647, the full compliance with the requirements of MSC.1/Circ.1647, including the fire safety requirements mentioned in [1.1.4], will be granted by the Society, subject to [1.1.2].

1.2 Documentation to be submitted

1.2.1

Tab 1 lists the plans, information, analysis, etc. which are to be submitted in addition to the information required in the other Parts of the Rules, for the portion of the yacht not involved in fuel cell power installations.

The Society reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Document
1	I	Technical specification of the fuel cell power installation, including technical data as power output parameters including min./max. design voltage and current, information about min/max temperature/pressure/rate of process air/cooling water/ventilation.
2	I	List of mechanical and electrical components which are part of the fuel cell power installation with specification of the pumps, compressors and fans.
3	A	P&I diagrams of systems conveying fuel (primary and reformed type), exhaust air/gas, cooling media, process air, technical water, ventilation, inerting and of other systems in the fuel cell power installation.
4	I	Description of thermal insulation and heat tracing, if any.
5	A	Construction details with strength analysis of fuel cell power installation frame and foundation, if any.
6	A	Construction drawings of all components of the reforming equipment considered as pressure vessel e.g. burner, reformer, heat exchangers.
7	I	Functional description of the fuel cell power installation including at least its design, safety principles, ventilation and gas detection concept, auxiliary systems arrangement (e.g. cooling medium, process air, ventilation, venting, process water, inert gas, as applicable).
8	A	Block diagram of the safety, control and monitoring system of the fuel cell power installation.
9	A	Wiring diagrams of power supply and automation system of the fuel cell power installation.
10	I	List of controlled and monitored parameters and cause and effect matrix with normal/emergency shutdown functions.
11	A	Hazardous zones categorization study with calculation according to IEC 60079-10 (using CFD simulations or empirical formula) and list of EX equipment with relevant EX certificates, as applicable.
12	A	Service profile description of the fuel cell power installations, highlighting if the fuel cell power generation is used for essential or non-essential services.
13	I	A FMEA according to the Tasneef "Guide for Failure mode and Effect Analysis" or other equivalent methods for the fuel cell power installation.
14	I	Lifecycle operational, maintenance and inspection manual of the fuel cell power installation.
15	I	Testing reports or type approval reference of the fuel cell power installation components such as fuel cell stacks, reforming equipment according to applicable international recognized standards.
(1) A = to be submitted for approval I = to be submitted for information		

1.3 Definitions MSC.1/Circ.1647 REFERENCE: para. 1.4

1.3.1

The terms used in this Appendix have the meanings defined in MSC.1/Circ.1647, para. 1.4 and in the Tasneef "Rules for the Type Approval of Fuel Cell Power Modules".

Terms not defined have the same meaning as in SOLAS chapter II-2 and the IGF Code.

1.3.2

Certified safe type: means electrical equipment that is certified safe by the relevant recognized authorities for operation in a flammable atmosphere based on a recognized standard.

Note 1: Refer to IEC 60079 series, Explosive atmospheres and IEC 60092-502:1999 Electrical Installations in Ships - Tankers - Special Features.

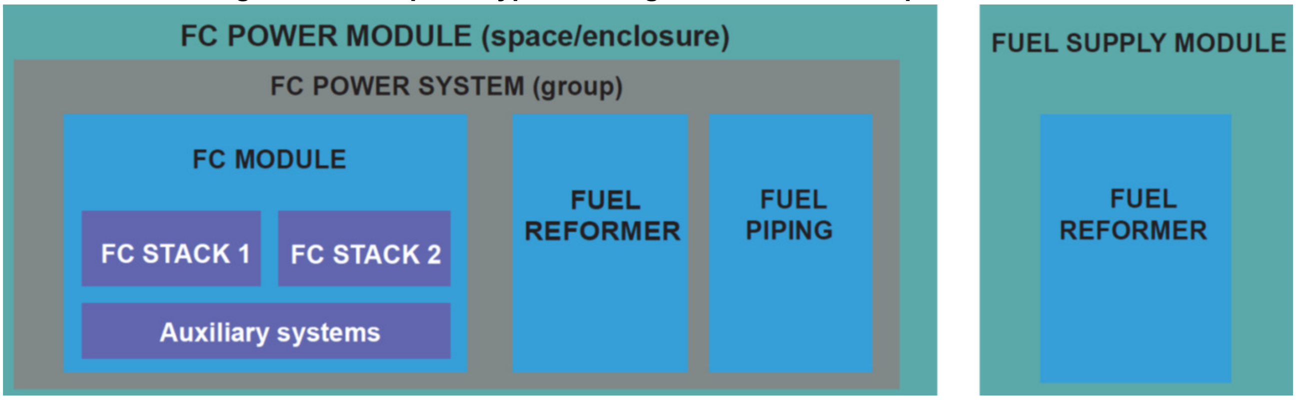
1.3.3
Fuel cell power module: is the fuel cell power system or parts of fuel cell power system and relevant enclosure.

1.3.4
Fuel cell module: is the assembly incorporating one or more fuel cell stacks and auxiliary systems.

1.3.5
Fuel supply module: is the enclosure containing the fuel reforming and fuel conditioning equipment.

1.3.6
Service profile: is a description of the use of the fuel cell for the power supply to on-board systems considering the operational profile of the yacht (navigation, maneuvering and port stay).

Figure 1 : Example of typical configuration of Fuel cell power module



2 Goal and functional requirements MSC.1/Circ.1647 REFERENCE: para. 1.2 and 1.3

2.1 Goal

2.1.1
The goal of this Appendix is to provide for safe and reliable delivery of electrical and/or thermal energy through the use of fuel cell technology.

2.2 Functional requirements

2.2.1
The safety, reliability and dependability of the systems is to be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery installations, regardless of the specific fuel cell type and fuel.

A FMEA consistent with the Tasneef “Guide for Failure Mode and Effect Analysis" is to be carried out for the whole fuel cell power installation to check the potential existence of failure modes that can jeopardize the yacht's safety. The results of the FMEA are then to be used to establish a trial program.

2.2.2
The probability and consequences of fuel-related hazards are to be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of gas leakage or failure of the risk reducing measures, necessary safety actions are to be initiated.

2.2.3
The design philosophy is to ensure that risk reducing measures and safety actions for the fuel cell power installation do not lead to an unacceptable loss of power.

2.2.4
Hazardous areas are to be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the yacht, persons on board, and equipment.

2.2.5
Equipment installed in hazardous areas are to be minimized to that required for operational purposes and are to be suitably and appropriately certified.

2.2.6

Unintended accumulation of explosive, flammable or toxic gas concentrations are to be prevented.

2.2.7

System components are to be protected against external damages.

2.2.8

Sources of ignition in hazardous areas are to be minimized to reduce the probability of explosions.

2.2.9

Piping systems and overpressure relief arrangements that are of suitable design, construction and installation for their intended application are to be provided.

2.2.10

Machinery, systems and components are to be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.

2.2.11

Fuel cell spaces are to be arranged and located such that a fire or explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable.

2.2.12

Suitable control, alarm, monitoring and shutdown systems are to be provided to ensure safe and reliable operation.

2.2.13

Fixed leakage detection suitable for all spaces and areas concerned is to be arranged.

2.2.14

Fire detection, protection and extinction measures appropriate to the hazards concerned are to be provided.

2.2.15

Commissioning, trials and maintenance of fuel systems and gas utilization machinery are to satisfy the goal in terms of safety, availability and reliability.

2.2.16

The technical documentation is to permit an assessment of the compliance of the system and its components with the applicable rules, guidelines, design standards used and the principles related to safety, availability, maintainability and reliability.

2.2.17

A single failure in a technical system or component is not to lead to an unsafe or unreliable situation.

The fuel cell power installations that:

- are used to power at least one essential service as defined in Sec 1, [3.2.1] , and
- are necessary to ensure the compliance of the main source of electrical power to the requirements in Sec 3, [2.2.3]

are to be specifically considered in terms of reliability, availability and redundancy.

2.2.18

Safe access is to be provided for operation, inspection and maintenance.

3 Alternative design MSC.1/Circ.1647 REFERENCE: para. 1.5

3.1

3.1.1

Appliances and arrangements of fuel cell power systems may deviate from those set out in this Appendix provided that they meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety of the relevant paragraphs.

3.1.2
The equivalence of the alternative design is to be demonstrated as specified in SOLAS regulation II-1/55, and approved by the Society. However, the Society will not allow operational methods or procedures as an alternative to a particular fitting, material, appliance, apparatus, item of equipment, or type thereof which is prescribed by this Appendix.

4 Design principles for fuel cell power installations MSC.1/Circ.1647 REFERENCE: para. 2

4.1 Fuel cell spaces

4.1.1
The requirements in MSC.1/Circ.1647 para. 2.1 apply.

4.2 Arrangement and access

4.2.1
The requirements in MSC.1/Circ.1647 para. 2.2 apply.

4.3 Atmospheric control of fuel cell spaces

4.3.1 General
The requirements in MSC.1/Circ.1647 para. 2.3.1 apply.

4.3.2 Ventilation of fuel cell spaces
The requirements in MSC.1/Circ.1647 para. 2.3.2 apply.

When applying the requirements in MSC.1/Circ.1647 para. 2.3.2.3, reference is to be made to IEC 60079-10 standard.

4.3.3 Inerting of fuel cell spaces for fire protection purposes
The requirements in MSC.1/Circ.1647 para. 2.3.3 apply.

4.4 Materials

4.4.1
The requirements in MSC.1/Circ.1647 para. 2.4 apply.

4.4.2
The use of plastic materials for piping and pressure vessels is in general not allowed. Specific application may be evaluated on case-by-case basis.

4.5 Piping arrangement for fuel cell power system

4.5.1
The requirements in MSC.1/Circ.1647 para. 2.5 apply.

4.5.2
Where the fuel cell stacks are subject to specific air quality requirements (e.g., limits on dust, humidity, salinity, temperature), arrangements for air conditioning, air drying and air filtering are to be fitted and the air quality parameters are to be monitored.

4.5.3
Where the primary fuel is subject to specific quality requirements (e.g., maximum Sulphur content) not to impair the performances of the fuel cell power system, arrangements for fuel conditioning system are to be fitted.

4.5.4
If enclosed fuel supply modules and enclosed fuel cell modules are installed, they are to be fitted with sampling point connections for detecting explosive atmosphere by means of portable equipment.

4.5.5
Where the pressure vessels and the piping in the fuel cell power module may be subject to overpressure, they are to be suitably protected by pressure relief arrangements. The discharge of possible hazardous gases is to be routed to open air.

4.6 Exhaust gas and exhaust air

4.6.1

Exhaust gases and exhaust air from the fuel cell power systems should not be combined with any ventilation and should be led to a safe location in the open air.

4.6.2

The arrangement of the process air treatment system is to be subject to the risk assessment as required in [6.3].

5 Fire safety MSC.1/Circ.1647 REFERENCE: para. 3

5.1

5.1.1

This paragraph is void, as the provisions of MSC.1/Circ.1647 para. 3 are not within the scope of classification.

These provisions are applied by the Society when acting on behalf of the flag Administration, within the scope of delegation (see [1.1.6]).

6 Electrical systems MSC.1/Circ.1647 REFERENCE: para. 4

6.1 General provisions on electrical systems

6.1.1

The requirements in MSC.1/Circ.1647 para. 4.1 apply.

6.1.2

For the casing of the fuel cell stack to be mounted in the fuel cell space, a minimum enclosure notation of IP54 is required to protect against:

a) ingress of dust in sufficient quantity to interfere with satisfactory operation of the fuel cell; and

b) water splashed against the fuel cell stack from any direction.

6.1.3

The equipment and installations in hazardous areas are to comply with recognized international standards including but not limited to the following:

- IEC 60079-0 General requirements
- IEC 60079-1 Flameproof enclosure 'Ex d'
- IEC 60079-7 Increased safety 'Ex e'
- IEC 60079-11 Intrinsic safety 'Ex i'
- IEC 60079-14 Installations
- IEC 60079-17 Electrical Installations inspection and maintenance
- IEC 60079-18 Molded encapsulation 'Ex m'
- IEC 60079-25 Intrinsically safe systems
- IEC 60079-29 Gas detection

The equipment is to be properly EX certified considering the hazardous zone categorization defined by manufacturer according to IEC 60079-10 or according to [6.2].

6.1.4

Earthing and bonding are to be arranged according to recognized international standards.

6.2 Area classification

6.2.1 General

The requirements in MSC.1/Circ.1647 para. 4.2.1 apply.

6.2.2 Hazardous areas zone 0

The requirements in MSC.1/Circ.1647 para. 4.2.2 apply.

6.2.3 Hazardous areas zone 1

The requirements in MSC.1/Circ.1647 para. 4.2.3 apply.

6.2.4 Hazardous areas zone 2

The requirements in MSC.1/Circ.1647 para. 4.2.4 apply.

6.2.5 Ventilation ducts

The requirements in MSC.1/Circ.1647 para. 4.2.5 apply.

6.3 Risk assessment

6.3.1

The requirements in MSC.1/Circ.1647 para. 4.3 apply.

6.3.2

Guidance on risk assessment techniques can be found in the Tasneef "Guide for Risk Analysis".

6.3.3

The assumptions for the risk assessment are to be agreed by a team of experts acceptable to the Society. It may include a representative of Class, Flag Administration, owner, builder or designer, and consultants having the necessary knowledge and experience in safety, design and/or operation as necessary for the specific evaluation at hand. Other members may include marine surveyors, operators, safety engineers, equipment manufacturers, human factors experts, naval architects and marine engineers, according to the problem under scope.

6.3.4

The risk assessment can be qualitative or quantitative and is to cover the following aspects:

- Accidental release and dispersion (hydrogen leakages due to tank and piping rupture and permeability, hydrogen dilution in enclosed space, hydrogen effects on material e.g. embrittlement or permeation)
- Ignition (spontaneous ignition of hydrogen during sudden release, minimum energy for ignition)
- Deflagration and detonation (hydrogen explosion hazards)
- Fires (jet fire, radiative heat fluxes, fire resistance of hydrogen system)
- Impact on people, asset and environment (severity of hydrogen incidents)
- Mitigation techniques (detection method, barriers, ventilation level)
- Emergency operation (strategy control of incident)
- Oxygen enrichment due to cryogenic hydrogen temperature.

6.3.5

The risk assessment is to follow the steps outlined below.

a) The team of experts is to conduct a Hazard Identification (HAZID) to agree on the scenarios to be subjected to the risk assessment, and on the assumptions regarding the most critical events (typically, connection failures causing an hydrogen or primary fuel release) considering also available internationally recognized standard (e.g. ISO/TR 15916) for the identification of hazards and risks.

b) Reasonable assumptions on the extent of connection failures or other selected events and the process parameters of the hydrogen and primary fuel are to be made by the team of experts, preferably on the basis of statistics available in the public domain or provided and documented by stakeholders.

c) Reasonable assumptions on the operation of ventilation system are to be made according to layout and procedures of the affected space.

d) In order to verify that the hydrogen and primary fuel release will not create flammable concentrations and to demonstrate the drip tray capacity for a liquid leakage, a specific simulation is to be set up, aimed at evaluating the maximum amount of hydrogen spilled and its cloud, the evaporation rate and the possibility to fully accommodate the liquid leakage in the drip tray. The dispersion of vapors resulting from hydrogen evaporation in the affected space is also to be ascertained in respect of explosive atmosphere.

e) The simulation is to be conducted by commercially available and validated tools (typically, by CFD tools). It is to focus on the calculation of the amount of hydrogen or primary fuel spilled before the stop of hydrogen and primary fuel flow. Other calculation methods (e.g. empirical formulas based on literature) will be subject to special consideration.

f) Reasonable assumptions are to be made by the expert team regarding detection time, hydrogen and primary fuel flow stop time and human reaction time, in case operators are credited in the emergency.

g) If the simulation demonstrates that the drip tray cannot accommodate the liquid spill, mitigating measures are to be provided and subjected to the same simulation process, to appreciate the risk reduction.

7 Control, monitoring and safety systems MSC.1/Circ.1647 REFERENCE: para. 5

7.1 General provisions on control, monitoring and safety systems

7.1.1

The requirements in MSC.1/Circ.1647 para. 5.1 apply.

7.1.2

The fuel cell power installation is to be provided with a safety system with the following characteristics:

- "fail safe" design, so that any failure of the safety system cannot result in an unsafe status for the fuel cell module
- independent from control and alarm system
- compliant with the requirements in Ch 3, Sec 2, [7].

7.2 Gas or vapour detection

7.2.1

The requirements in MSC.1/Circ.1647 para. 5.2 apply.

7.3 Ventilation performance

7.3.1

The requirements in MSC.1/Circ.1647 para. 5.3 apply.

7.4 Bilge wells

7.4.1

The requirements in MSC.1/Circ.1647 para. 5.4 apply.

7.5 Manual emergency shutdown

7.5.1

The requirements in MSC.1/Circ.1647 para. 5.5 apply.

7.6 Actions of the alarm system and safety system

7.6.1

The requirements in MSC.1/Circ.1647 para. 5.6 apply.

7.7 Alarms

7.7.1

The requirements in MSC.1/Circ.1647 para. 5.7 apply.

7.8 Safety actions

7.8.1

The requirements in MSC.1/Circ.1647 para. 5.8 apply.

8 Tests on board

8.1 Functioning Tests

8.1.1

Where the fuel cell power installation provides power to the electric propulsion system, it is to be verified that the yacht has adequate management system of propulsion power in all sailing conditions including maneuvering, according to Ch 1, Sec 16, [3.7].

8.1.2

The fuel cell space ventilation system is to be tested prior to the commencement of the sea trials with the verification of the following items:

- air flow of all fans according to the required capacity as per hazardous zone categorization
- alarms and/or automatic shutdown in case of loss or reduction of required ventilation rate
- gas tightness of all flexible connections of fans to duct
- local and remote functioning test of dampers.

8.1.3

The fuel cell space inerting system is to be tested prior the commencement of the sea trials with the verification of the following items:

- functioning of inert gas generator or inert gas storage means (e.g. bottles)
- purging of fuel cell space piping conveying hydrogen and primary fuel.

8.1.4

The fuel cell space gas detection system is to be tested according to international recognized standard prior the commencement of the sea trials.

8.1.5

The following fuel cell power system items are to be tested:

- all automatic safety shutdowns
- emergency safety shutdown (manual ESD) at maximum power load
- protective devices (e.g. safety and automatic shut-off valves)
- measurements systems (e.g. level indicators, temperature measurement devices, pressure gauges).

8.1.6

The performance test for the fuel cell power system is to be carried out considering the service profile and is to demonstrate that the fuel cell generated power will meet the performance requirements to be previously agreed with Tasneef. During all testing the ambient conditions (air temperature, air pressure and humidity) are to be recorded. Moreover, as a minimum, the following fuel cell power module data are to be measured, recorded and compared with the targeted values:

- Nominal Load Point [A]
- Total Voltage [V]
- Total Current [A]
- Total Power [kW]
- Primary Fuel Consumption [kg/h]
- Fuel Inlet Pressure [bar]
- Fuel Inlet Temperature [C°]
- Cooling Water Inlet Temperature [C°]
- Cooling Water Outlet Temperature [C°]
- Ventilation air flow
- Process air flow

The typical polarization curve (cell voltage vs current) of the fuel cell power system, as created during factory acceptance test, is to be made available on board for prompt reference.

8.1.7

The performance tests are to be carried out considering the following conditions:

- start up, ramp up, rump down and automatic shutdown of the fuel cell power system
- load variations and load shedding as per service profile
- interactions with other sources of power, including change-over with the emergency power source.

8.2 Hot spot verification

8.2.1

Thermal imaging scanning of equipment where hot surfaces may be expected is to be carried out within the fuel cell power installation under steady and normal operating conditions, according to Ch 1, Sec 2, [6.10.9]. The requirements in Ch 1, Sec 1, [3.7.1] apply.

9 Material Test, Workshop inspections and testing

9.1 General principles

9.1.1

The provisions in this section are to be used in conjunction with the applicable requirements on materials and testing in other parts of these Rules and Tasneef "Rules for Testing and Certification of Marine Materials and Equipment".

9.1.2

Inspection and testing of fuel piping systems are to comply with Ch 1, Sec 10, [21].

9.1.3

All pressure vessels and piping conveying the primary fuel and the reformed fuel belong to Class I piping systems according to Ch 1, Sec 3 and Ch 1, Sec 10.

Outer pipes of double wall fuel piping arrangements are to be considered to belong to Class II piping systems.

9.1.4

The venting and ventilation lines conveying the exhaust air from fuel cell stack cathode side and the exhaust gas from reforming equipment or from fuel cell stack anode side are to be connected with butt welded joints as far as practicable. Alternatively, the use of type approved mechanical joints or other type of connections may be evaluated on case-by-case basis. These lines, if categorized as hazardous, are to be considered to belong to Class I piping systems.

9.2 Type approval

9.2.1

Fuel cell modules are to be provided with type approval certificate according to Tasneef "Rules for the Type Approval of Fuel Cell Power modules".

9.2.2

The piping components such as flexible hoses, mechanical joints and plastic pipes are to be provided with type approval certificates according to Ch 1, Sec 10.

9.2.3

The electronic and electrical components (e.g. sensors, cables, panels) are to be provided with type approval certificates according to Sec 15, [2].

9.3 Production testing

9.3.1

The fuel cell power system is subject to functioning test at workshop under Tasneef surveyor´s attendance on the basis of previously agreed test program taking into consideration the service profile and the availability of the type approval certificates for the fuel cell modules.

9.3.2

Pressure vessels belonging to the fuel cell power system are subject to testing according to Ch 1, Sec 3, [7].

9.3.3

The electrical installations for the fuel cell power conditioning are subject to testing according to Sec 15.

9.3.4

The automation system components are subject to testing according to Ch 3, Sec 6.

Chapter 3

AUTOMATION

SECTION 1 GENERAL

1 General

1.1 Field of application

1.1.1 The following requirements apply to automation systems, installed on all yachts, intended for essential services as defined in Ch 2, Sec 1. They also apply to systems required in Chapter 1 and Chapter 2, installed on all yachts.

1.1.2 This chapter is intended to avoid that failures or malfunctions of automation systems associated with essential and non-essential services cause danger to other essential services.

1.1.3 Requirements for unattended machinery spaces and for additional notations are specified in Part F Ch.2.

1.2 Regulations and standards

1.2.1 The regulations and standards applicable are those defined in Ch 2, Sec 1.

1.3 Definitions

1.3.1 Unless otherwise stated, the terms used in this chapter have the definitions laid down in Ch 2, Sec 1 or in the IEC standards. The following definitions also apply:

- Alarm indicator is an indicator which gives a visible and/or audible warning upon the appearance of one or more faults to advise the operator that his attention is required.
- Alarm system is a system intended to give a signal in the event of abnormal running condition.
- Application software is a software performing tasks specific to the actual configuration of the programmable electronic system and supported by the basic software.
- Automatic control is the control of an operation without direct or indirect human intervention, in response to the occurrence of predetermined conditions.
- Automation systems are systems including control systems and monitoring systems.
- Basic software is the minimum software, which includes firmware and middleware, required to support the application software.
- Cold standby system is a duplicated system with a manual commutation or manual replacement of cards which are live and non-operational. The duplicated system is to be able to achieve the operation of the main system with identical performance, and be operational within 10 minutes.
- Programmable electronic system is a system of one or more computers, associated software, peripherals and interfaces, and the computer network with its protocol.
- Control station is a group of control and monitoring devices by means of which an operator can control and verify the performance of equipment.
- Control system is a system by which an intentional action is exerted on an apparatus to attain given purposes.
- Expert system is an intelligent knowledge-based system that is designed to solve a problem with information that has been compiled using some form of human expertise.
- Fail safe is a design property of an item in which the specified failure mode is predominantly in a safe direction with regard to the safety of the , as a primary concern.
- Full redundant is used to describe an automation system comprising two (identical or non-identical) independent systems which perform the same function and operate simultaneously.
- Hot standby system is used to describe an automation system comprising two (identical or non-identical) independent systems which perform the same function, one of which is in operation while the other is on standby with an automatic change-over switch.
- Instrumentation is a sensor or monitoring element.
- Integrated system is a system consisting of two or more subsystems having independent functions connected by a data transmission network and operated from one or more workstations.
- Local control is control of an operation at a point on or adjacent to the controlled switching device.

- Manual control is control of an operation acting on final control devices either directly or indirectly with the aid of electrical, hydraulic or mechanical power.
- Monitoring system is a system designed to observe the correct operation of the equipment by detecting incorrect functioning (measure of variables compared with specified value).
- Safety system is a system intended to limit the consequence of failure and is activated automatically when an abnormal condition appears.
- Software is the program, procedures and associated documentation pertaining to the operation of the computer system.
- Redundancy is the existence of more than one means for performing a required function.
- Remote control is the control from a distance of apparatus by means of an electrical or other link.

1.4 General

1.4.1 The automation systems and components, as indicated in Ch 2, Sec 15, [2], are to be chosen from among the list of type approved products when required by Pt A ch 2 App.3.

They are to be approved on the basis of the applicable requirements of these Rules and in particular those stated in this Chapter.

Case by case approval may also be granted at the discretion of the Society, based on submission of adequate documentation and subject to the satisfactory outcome of any required tests.

1.4.2 Main and auxiliary machinery essential for the propulsion, control and safety of the yacht shall be provided with effective means for its operation and control.

1.4.3 Control, alarm and safety systems are to be based on the fail-to-safety principle.

1.4.4 Failure of automation systems is to generate an alarm.

1.4.5 Detailed indication, alarm and safety requirements regarding automation systems for individual machinery and installations are to be found in Chapter 1.

2 Documentation

2.1 General

2.1.1 Before the actual construction is commenced, the Manufacturer, Designer or builder is to submit to the Society the documents (plans, diagrams, specifications and calculations) requested in this Section.

The list of documents requested is to be intended as guidance for the complete set of information to be submitted, rather than an actual list of titles.

The Society reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

Plans are to include all the data necessary for their interpretation, verification and approval.

2.2 Documents to be submitted

2.2.1 The documents listed in Tab 1 are to be submitted.

Table 1 : Documentation to be submitted

No.	I/A **(1)**	Documentation
1	A	The general specification for the automation of the yacht
2	A	The detailed specification of the essential service systems
3	A	The list of components used in the automation circuits, and references (Manufacturer, type, etc.)
4	I	Instruction manuals
5	I	Test procedures for control, alarm and safety systems
6	A	A general diagram showing the monitoring and/or control positions for the various installations, with an indication of the means of access and the means of communication between the positions as well as with the engineers
(1) A = to be submitted for approval; I = to be submitted for information.		

No.	I/A **(1)**	Documentation
7	A	The diagrams of the supply circuits of automation systems, identifying the power source
8	A	The list of monitored parameters for alarm/monitoring and safety systems
9	A	Diagram of the engineers' alarm system
10	A	Single line diagram of the automation system, with indication of the connections, data links and power supplies of all equipment
(1) A = to be submitted for approval; I = to be submitted for information.		

Table 2 : Documentation to be submitted for programmable electronic systems

No.	I/A **(1)**	Documentation **(2)**
1	A	System block diagram, showing the arrangement of individual parts, input and output devices and interconnections
2	A	Wiring connection diagrams, including details of electrical power supplies, and of input and output devices
3	A	System functional description
4	I	Software system description and documentation
5	I	User interface description
6	I	Test programs
(1) A = to be submitted for approval; I = to be submitted for information. **(2)** See as guidance IEC 60092-504 clause 10.11		

2.3 Documents for programmable electronic system

2.3.1 General

For programmable electronic systems, the documents listed in Tab 2 are to be submitted.

2.3.2 System description, computer software

This documentation is to contain:

- a list of all main software modules installed per hardware unit with names and version numbers
- a description of all main software which is to include at least:
  - a description of basic software installed per hardware unit, including communication software, when applicable
  - a description of application software.

2.3.3 Description of computer hardware

The documentation to be submitted is to include:

- hardware information of importance for the application and a list of documents that apply to the system.
- the supply circuit diagram
- a description of hardware and software tools for equipment configuration
- the information to activate the system
- general information for trouble shooting and repair when the system is in operation.

2.3.4 System reliability analysis

The documentation to be submitted is to demonstrate the reliability of the system by means of appropriate analysis such as:

- a failure mode analysis describing the effects due to failures leading to the destruction of the automation system. In addition, this documentation is to show the consequences on other systems, if any. This analysis is appraised in accordance with the IEC Publication 60812, or a recognised standard
- test report /life test
- MTBF calculation (Mean Time Between Failure)
- any other documentation demonstrating the reliability of the system.

2.3.5 User interface description

The documentation is to contain:

- a description of the functions allocated to each operator interface (keyboard/screen or equivalent)
- a description of individual screen views (schematics, colour photos, etc.)
- a description of how menus are operated (tree presentation)
- an operator manual providing necessary information for installation and use.

2.3.6 Test programs

The following test programs are to be submitted:

- software module/unit test
- software integration test
- system validation test
- on-board test.

Each test program is to include:

- a description of each test item
- a description of the acceptance criteria for each test.

2.4 Documents for type approval of equipment

2.4.1 Documents to be submitted for type approval of equipment are listed hereafter:

- a request for type approval from the manufacturer or his authorized representative
- the technical specification and drawings depicting the system, its components, characteristics, working principle, installation and conditions of use and, when there is a programmable electronic system, the documents listed in Tab 2
- any test reports previously prepared by specialised laboratories.

3 Environmental and supply conditions

3.1 General

3.1.1 General

The automation system is to operate correctly when the power supply is within the range specified in Sec 2.

3.1.2 Environmental conditions

The automation system is to be designed to operate satisfactorily in the environment in which it is located. The environmental conditions are described in Ch 2, Sec 2.

3.1.3 Failure behaviour

The automation system is to have non-critical behaviour in the event of power supply failure, faults or restoration of operating condition following a fault. If a redundant power supply is used, it must be taken from an independent source.

3.2 Power supply conditions

3.2.1 Electrical power supply

The conditions of power supply to be considered are defined in Ch 2, Sec 2.

3.2.2 Pneumatic power supply

For pneumatic equipment, the operational characteristics are to be maintained under permanent supply pressure variations of ± 20% of the rated pressure.

Detailed requirements are given in Ch 1, Sec 10.

3.2.3 Hydraulic power supply

For hydraulic equipment, the operational characteristics are to be maintained under permanent supply pressure variations of ± 20% of the rated pressure.

Detailed requirements are given in Ch 1, Sec 10.

4 Materials and construction

4.1 General

4.1.1 The choice of materials and components is to be made according to the environmental and operating conditions in order to maintain the proper function of the equipment.

4.1.2 The design and construction of the automation equipment is to take into account the environmental and operating conditions in order to maintain the proper function of the equipment.

4.2 Type approved components

4.2.1 See Ch 2, Sec 15.

SECTION 2 DESIGN REQUIREMENTS

1 General

1.1

1.1.1 All control systems essential for the propulsion, control and safety of the yacht shall be independent or designed such that failure of one system does not degrade the performance of another system.

1.1.2 Controlled systems are to have manual operation.

Failure of any part of such systems shall not prevent the use of the manual override.

1.1.3 Automation systems are to have constant performance.

1.1.4 Safety functions are to be independent of control and monitoring functions. As far as practicable, control and monitoring functions are also to be independent.

1.1.5 Control, monitoring and safety systems are to have self-check facilities. In the event of failure, an alarm is to be activated.

In particular, failure of the power supply of the automation system is to generate an alarm.

1.1.6 When a programmable electronic system is used for control, alarm or safety systems, it is to comply with the requirements of Sec 3.

2 Power supply of automation systems

2.1 General

2.1.1

Automation systems are to be powered from two sources of power by means of two independent feeders. Failure of each of these power supplies is to generate an alarm.

Batteries or pneumatic or hydraulic accumulators, installed to allow the system to be continuously powered, are not considered as a duplication of the power supply.

Note 1: batteries constituting the emergency source of electrical power may be considered as one of the two required sources.

2.1.2

Power supply circuits are to be such that no direct connections to any point of the 's main power supply system are provided (e.g. by means of isolating transformers).

2.1.3

Each automation system is to be have separate power supplies with short circuit and overload protection.

Safety systems are to have power supplies as far as possible separate from control and alarm system, or an equivalent safety level is to be ensured.

2.1.4

In addition to what above, the automation systems are to be continuously powered by means of batteries or pneumatic or hydraulic accumulators.

2.1.5

The capacity of the batteries, or pneumatic or hydraulic accumulators is to be sufficient to allow the normal operation of the alarm and safety system for at least half an hour.

3 Control systems

3.1 General

3.1.1 In the case of failure, the control systems used for essential services are to remain in their last position they had before the failure.

3.2 Local control

3.2.1 Each system is to be able to be operated manually from a position located so as to enable visual control of operation. For detailed instrumentation for each system, refer to Chapter 1and Chapter 2.

It shall also be possible to control the auxiliary machinery, essential for the propulsion and safety of the yacht, at or near the machinery concerned.

3.3 Remote control systems

3.3.1 When several control stations are provided, control of machinery is to be possible at one station at a time.

3.3.2 At each location there shall be an indicator showing which location is in control of the propulsion machinery.

3.3.3 Remote control is to be provided with the necessary instrumentation, in each control station, to allow effective control (correct function of the system, indication of control station in operation, alarm display).

3.3.4 When transferring the control location, no significant alteration of the controlled equipment is to occur. Transfer of control is to be protected by an audible warning and acknowledged by the receiving control location. The main control location is to be able to take control without acknowledgement.

3.4 Automatic control systems

3.4.1 Automatic starting, operational and control systems shall include provisions for manually overriding the automatic controls.

3.4.2 Automatic control is to be stable in the range of the controller in normal working conditions.

3.4.3 Automatic control is to have instrumentation to verify the correct function of the system.

4 Control of propulsion machinery

4.1 Remote control

4.1.1 The requirements mentioned in [3] are to be applied for propulsion machinery.

4.1.2 The design of the remote control system shall be such that in case of its failure an alarm will be given.

4.1.3 Supply failure (voltage, fluid pressure, etc.) in propulsion plant remote control is to activate an alarm at the control position. In the event of remote control system failure and unless the Society considers it impracticable, the preset speed and direction of thrust are to be maintained until local control is in operation. This applies in particular in the case of loss of electric, pneumatic or hydraulic supply to the system.

4.1.4 Propulsion machinery orders from the navigation bridge shall be indicated in the main machinery control room, and at the manoeuvring platform (if any).

4.1.5 The control shall be performed by a single control device for each independent propeller, with automatic performance of all associated services, including, where necessary, means of preventing overload of the propulsion machinery. Where multiple propellers are designed to operate simultaneously, they must be controlled by one control device.

4.1.6 Indicators shall be fitted on the navigation bridge, in the main machinery control room and at the manoeuvring platform, for:

propeller speed and direction of rotation in the case of fixed pitch propellers; and

propeller speed and pitch position in the case of controllable pitch propellers.

4.1.7 The main propulsion machinery shall be provided with an emergency stopping device on the navigation bridge which shall be independent of the navigation bridge control system.

In the event that there is no reaction to an order to stop, provision is to be made for an alternative emergency stop. This emergency stopping device may consist of a simple and clearly marked control device, for example a push-button. This fitting is to be capable of suppressing the propeller thrust, whatever the cause of the failure may be.

4.2 Remote control from navigating bridge

4.2.1 Where propulsion machinery is controlled from the navigating bridge, the remote control is to include an automatic device such that the number of operations to be carried out is reduced and their nature is simplified and such that control is possible in both the ahead and astern directions. Where necessary, means for preventing overload and running in critical speed ranges of the propulsion machinery is to be provided.

4.2.2 On board yachts fitted with remote control, direct control of the propulsion machinery is to be provided locally. The local direct control is to be independent from the remote control circuits, and takes over any remote control when in use.

4.2.3 Each local control position, including partial control (e.g. local control of controllable pitch propellers or clutches) is to be provided with means of communication with each remote control position. The local control positions are to be independent from remote control of propulsion machinery and continue to operate in the event of a blackout (see Note 1 in [4.2.1]).

4.2.4 Remote control of the propulsion machinery shall be possible only from one location at a time; at such locations interconnected control positions are permitted.

4.2.5 The transfer of control between the navigating bridge and machinery spaces shall be possible only in the main machinery space or the main machinery control room. The system shall include means to prevent the propelling thrust from altering significantly, when transferring control from one location to another (see Note 1 in [4.2.1]).

4.2.6 At the navigating bridge, the control of the routine manoeuvres for one line of shafting is to be performed by a single control device: a lever, a handwheel or a push-button board. However each mechanism contributing directly to the propulsion, such as the engine, clutch, automatic brake or controllable pitch propeller, is to be able to be individually controlled, either locally or at a central monitoring and control position in the engine room (see Note 1 in [4.2.1]).

4.2.7 Remote starting of the propulsion machinery is to be automatically inhibited if a condition exists which may damage the machinery, e.g. shaft turning gear engaged, drop of lubrication oil pressure or brake engaged.

4.2.8 As a general rule, the navigating bridge panels are not to be overloaded by alarms and indications which are not required.

4.3 Automatic control

4.3.1 The requirements in [3] are applicable. In addition, the following requirements are to be considered, if relevant.

4.3.2 Main turbine propulsion machinery and, where applicable, main internal combustion propulsion machinery and auxiliary machinery shall be provided with automatic shutoff arrangements in the case of failures such as lubricating oil supply failure which could lead rapidly to complete breakdown, serious damage or explosion.

4.3.3 The automatic control system is to be designed on a fail safe basis, and, in the event of failure, the system is to be adjusted automatically to a predetermined safe state.

4.3.4 When the remote control system of the propulsion machinery includes automatic starting, the number of automatic consecutive attempts is to be limited at a preset value of the starting air pressure permitting 3 attempts, and an alarm is to be provided, on the navigation bridge and in the machinery space.

4.3.5 Operations following any setting of the bridge control device (including reversing from the maximum ahead service speed in case of emergency) are to take place in an automatic sequence and with acceptable time intervals , as prescribed by the manufacturer.

4.4 Automatic control of propulsion and manoeuvring units

4.4.1 When the power source actuating the automatic control of propelling units fails, an alarm is to be triggered. In such case, the preset direction of thrust is to be maintained long enough to allow the intervention of engineers. Failing this, minimum arrangements, such as stopping of the shaft line, are to be provided to prevent any unexpected reverse of the thrust. Such stopping may be automatic or ordered by the operator, following an appropriate indication.

4.5 Clutches

4.5.1 Where the clutch of a propulsion engine is operated electrically, pneumatically or hydraulically, an alarm is to be given at the control station in the event of loss of energy; as far as practicable, this alarm is to be triggered while it is still possible to operate the equipment (see Note 1 in [4.2.1]).

4.5.2 When only one clutch is installed, its control is to be fail-set. Other arrangements may be considered in relation to the configuration of the propulsion machinery.

4.6 Brakes

4.6.1 Automatic or remote controlled braking is to be possible only if:

- propulsion power has been shut off
- the turning gear is disconnected
- the shaftline speed (r.p.m.) is below the threshold stated by the builder (see Note 1 in [4.2.1]).

5 Remote control of valves

5.1

5.1.1 The following requirements are applicable to valves whose failure could impair essential services.

5.1.2 Failure of the power supply is not to permit a valve to move to an unsafe condition.

5.1.3 An indication is to be provided at the remote control station showing the actual position of the valve or whether the valve is fully open or fully closed.

5.1.4 In case of failure of manually operated or automatic remote control systems, the local control of valves is to be possible.

5.1.5 Equipment located in places which may be flooded is to be capable of operation even if submerged.

6 Alarm system

6.1 General requirements

6.1.1 Alarms are to be visual and audible and are to be clearly distinguishable, in the ambient noise and lighting in the normal position of the personnel, from any other signals.

6.1.2 Sufficient information is to be provided for proper handling of alarms.

6.1.3 The alarm system is to be of the self-check type; failure within the alarm system, including the outside connection, is to activate an alarm. The alarm circuits are to be independent from each other. All alarm circuits are to be protected so as not to endanger each other.

6.2 Alarm functions

6.2.1 Alarm activation

Alarms are to be activated when abnormal conditions appear in the machinery, which need the intervention of personnel on duty, and on the automatic change-over, when standby machines are installed.

An existing alarm is not to prevent the indication of any further fault.

6.2.2 Acknowledgement of alarm

The acknowledgment of an alarm consists in manually silencing the audible signal and additional visual signals (e.g. rotating light signals) while leaving the visual signal on the active control station. Acknowledged alarms are to be clearly distinguishable from unacknowledged alarms. Acknowledgement should not prevent the audible signal to operate for new alarm.

Alarms shall be maintained until they are accepted and visual indications of individual alarms shall remain until the fault has been corrected, when the alarm system shall automatically reset to the normal operating condition.

Acknowledgement of alarms is only to be possible at the active control station.

Alarms, including the detection of transient faults, are to be maintained until acknowledgement of the visual indication.

Acknowledgement of visual signals is to be separate for each signal or common to a limited group of signals. Acknowledgement is only to be possible when the user has visual information on the alarm condition for the signal or all signals in a group.

6.2.3 Locking of alarms

Manual locking of separate alarms may be accepted when this is clearly indicated.

Locking of alarm and safety functions in certain operating modes (e.g. during start-up or trimming) is to be automatically disabled in other modes.

6.2.4 Time delay of alarms

It is to be possible to delay alarm activation in order to avoid false alarms due to normal transient conditions (e.g. during start-up or trimming).

6.2.5 Engineers' alarm

An engineers' alarm shall be provided to be operated from the engine control room or at the manoeuvring platform as appropriate, and shall be clearly audible in the engineers' accommodation.

6.2.6 Transfer of responsibility

Where several alarm control stations located in different spaces are provided, responsibility for alarms is not to be transferred before being acknowledged by the receiving location. Transfer of responsibility is to give an audible warning. At each control station it is to be indicated which location is in charge.

6.2.7 Alarm systems with limited number of monitored positions

For alarms with a limited number of monitored positions, relaxation to the requirements of [6.2] may be granted at judgement of the Society.

7 Safety system

7.1 Design

7.1.1 System failures

A safety system is to be designed so as to limit the consequence of failures. It is to be constructed on the fail-to-safety principle.

The safety system is to be of the self-check type; as a rule, failure within the safety system, including the outside connection, is to activate an alarm.

7.2 Function

7.2.1 Safety activation

The safety system is to be activated automatically in the event of identified conditions which could lead to damage of associated machinery or systems, such that:

- normal operating conditions are restored (e.g. by the starting of the standby unit), or
- the operation of the machinery is temporarily adjusted to the prevailing abnormal conditions (e.g. by reducing the output of the associated machinery), or
- the machinery is protected, as far as possible, from critical conditions by shutting off the fuel or power supply, thereby stopping the machinery (shutdown), or appropriate shutdown.

7.2.2 Safety indication

When the safety system has been activated, it is to be possible to trace the cause of the safety action. This is to be accomplished by means of a central or local indication.

When a safety system is made inoperative by a manual override, this is to be clearly indicated at corresponding control stations.

Automatic safety actions are to activate an alarm at predefined control stations.

7.3 Shutdown

7.3.1 For shutdown systems of machinery, the following requirements are to be applied:

- when the system has stopped a machine, the latter is not to be restarted automatically before a manual reset of the safety system has been carried out
- the shutdown of the propulsion system is to be limited to those cases which could lead to serious damage, complete breakdown or explosion.

7.4 Standby systems

7.4.1 For the automatic starting system of the standby units, the following requirements are to be applied:

- faults in the electrical or mechanical system of the running machinery are not to prevent the standby machinery from being automatically started
- when a machine is on standby, ready to be automatically started, this is to be clearly indicated at its control position
- the change-over to the standby unit is to be indicated by a visual and audible alarm
- means are to be provided close to the machine, to prevent undesired automatic or remote starting (e.g. when the machine is being repaired)
- automatic starting is to be prevented when conditions are present which could endanger the standby machine.

7.5 Testing

7.5.1 The safety systems are to be tested in accordance with the requirements in Sec 6.

SECTION 3 COMPUTER BASED SYSTEMS

1 Scope

1.1 General

1.1.1

These Requirements apply to design, construction, commissioning and maintenance of computer based systems where they depend on software for the proper achievement of their functions and focus on the functionality of the software and on the hardware supporting the software.

1.1.2

These Requirements apply to the use of computer based systems which provide control, alarm, monitoring, safety or internal communication functions which are subject to classification requirements.

1.1.3

Computer-based systems that are covered by statutory regulations are excluded from the requirements of this Section.

Guidance:

Examples of such systems are navigation systems and radio communication system required by SOLAS chapter V and IV, and vessel loading instrument/stability computer.

For loading instrument/stability computer, IACS recommendation no. 48 may be considered

1.2 Reference to other regulations and standards

1.2.1

For the purposes of this Section, the applicable requirements in Sec 6 are to be complied with.

1.2.2

For the purposes of this Section,the following standards are listed for information and may be used for the development of hardware/software of computer based systems:

- IEC 61508 "Functional safety of electrical/electronic/programmable electronic safety related Systems"
- ISO/IEC 12207 "Systems and software engineering - Software life cycle processes"
- ISO 9001"Quality Management Systems - Requirements"
- ISO/IEC 90003 "Software engineering - Guidelines for the application of ISO 9001 to computer software"
- IEC 60092-504 "Electrical installations in s - Part 504: Special features - Control and instrumentation"
- ISO/IEC 25000 "Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - Guide to SQuaRE"
- ISO/IEC 25041 "Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - Evaluation guide for developers, acquirers and independent evaluators"
- IEC 61511 "Functional safety - Safety instrumented systems for the process industry sector"
- ISO/IEC 15288 "Systems and software engineering - system life cycle process".
- ISO 90007 Quality management - Guidelines for configuration management
- ISO 24060 Ships and marine technology - Ship software logging system for operational technology.

Other industry standards may be considered.

1.3 Structure

1.3.1

The general certification requirements for computer-based systems and the relation to type approval is described in [2]. The requirements and extent of verification of a computer- based system depends on its categorization into one of three categories. The categories are described in [3].

The requirements of this Section cover the lifecycle of computer-based system from design through operations. The requirements are split into groups representing the different phases of the life cycle and the roles responsible for fulfilling the requirements.

The activities related to the development and delivery of a computer-based system is described in [4], while the activities related to the maintenance in the operational phase are described in [5].

Management of changes to software and systems is given special attention in this Section, and the main aspects of a management of change process are described in [6].

Most requirements in this Section are related to the way of working, and thus focus on activities to be performed, but it also contains some technical requirements. The technical requirements on computer-based systems have been gathered in [7].

Each activity contains a requirement part which describes the minimum requirements on the role in question, and a part which describes the Society's verification of the activity in question.

1.4 Abbreviations

1.4.1

For the purpose of this Section the abbreviations in Tab 1 apply.

Table 1 : Abbreviations

Abbreviation	Expansion
Cat I	Category one systems as defined in [3.1]
Cat II	Category two systems as defined in [3.1]
Cat III	Category three systems as defined in [3.1]
COTS	Commercial off-the-shelf
FAT	Factory acceptance test
FMEA	Failure mode and effect analysis
IT	Information technology
OT	Operational technology
PMS	Planned maintenance system
SAT	System acceptance test
SOST	System of systems test
SSLS	Ship software logging system

1.5 Definitions

1.5.1 Black-box description

A description of a system’s functionality and behaviour and performance as observed from outside the system in question.

1.5.2 Black-box test methods

Verification of the functionality, performance, and robustness of a system, sub-system or component by only manipulating the inputs and observing the outputs. This does not require any knowledge of the system’s inner workings and focuses only on the observable behaviour of the system/component under test in order to achieve the desired level of verification.

1.5.3 Computer-based system (CBS)

A programmable electronic device, or interoperable set of programmable electronic devices, organized to achieve one or more specified purposes such as collection, processing, maintenance, use, sharing, dissemination, or disposition of information. CBSs onboard include IT and OT systems. A CBS may be a combination of subsystems connected via network. Onboard CBSs may be connected directly or via public means of communications (e.g. Internet) to ashore CBSs, other vessels’ CBSs and/or other facilities.

1.5.4 Failure mode description

A document describing the effects due to failures in the system, not failures in the equipment supported by the system. The following aspects shall be covered:

- list of failures which are subject to assessment, with
- description of the system response to each of the above failures
- comments to the consequence of each of these failures.

1.5.5 Owner

The organization or person which orders the vessel in the construction phase or the organization which owns or manages the vessel in service. In the context of this Section this is a defined role with specific responsibilities..

1.5.6 Parameterization

To configure and tune system and software functionality by changing parameters. It does not usually require-computer programming and is normally done by the system supplier or a service provider, not the operator or end-user.

1.5.7 Programmable device

Physical component where software is installed.

1.5.8 Robustness

The ability to respond to abnormal inputs and conditions.

1.5.9 Systems integrator

Single organization or a person coordinating interaction between suppliers of systems and sub-systems on all stages of life cycle of computer-based systems in order to integrate them into a verified vessel-wide system of systems and to provide proper operation and maintenance of the computer-based systems. In the context of this Section this is a defined role with specific responsibilities. During the design and delivery phase the Shipyard is the default Systems integrator, during operations phase the Owner is the default.

1.5.10 Service supplier

A person or company, not employed by an IACS Member, who at the request of an equipment manufacturer, shipyard, vessel's owner or other client acts in connection with inspection work and provides services for a yacht or a mobile offshore unit such as measurements, tests or maintenance of safety systems and equipment, the results of which are used by surveyors in making decisions affecting classification or statutory certification and services.

1.5.11 Supplier

A generic term used for any organisation or person that is a contracted or a subcontracted provider of services, system components, or software.

1.5.12 System

A combination of components, equipment and logic which has a defined purpose, functionality, and performance. In the context of this Section, a specific system is delivered by one system supplier.

1.5.13 System of systems

A system which is made up of several systems.

In the context of this Section, the system of systems encompasses all monitoring, control and safety systems delivered from the Shipyard as a part of a vessel.

1.5.14 System supplier

An organisation or person that is contracted or a subcontracted provider of system components or software under the coordination of the Systems integrator. In the context of this Section this is a defined role with specific responsibilities.

1.5.15 Sub-system

Identifiable part of a system, which may perform a specific function or set of functions.

1.5.16 Programmable device

Physical component where software is installed.

1.5.17 Software component

A standalone piece of code that provides specific and closely coupled functionality.

1.5.18 Software master files

The computer-files that constitutes the original source of the software. For custom made software this may be readable source-code files, and for COTS software it may be different forms of binary files.

1.5.19 Software-structure

Overview of how the different software components interact and is commonly referred to as the Software Architecture, or Software Hierarchy.

1.5.20 Simulation tests

Monitoring, control, or safety system testing where the equipment under control is partly or fully replaced with simulation tools, or where parts of the communication network and lines are replaced with simulation tools.

1.5.21 Society Certificate

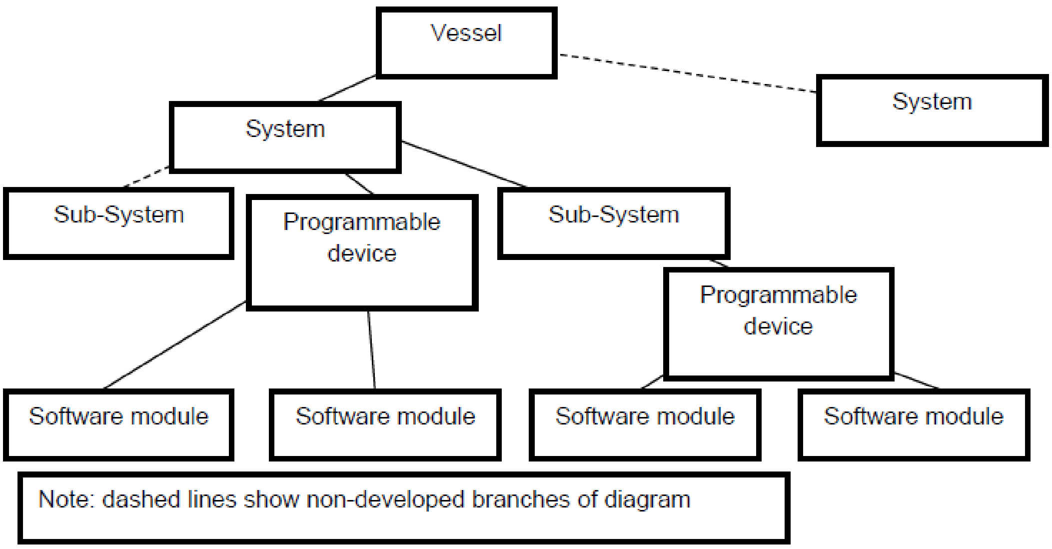
Compliance document issued by a Class Society stating:

- conformity with applicable rules and requirements
- that the tests and inspections have been carried out on
- the finished certified component itself; or
- on samples taken from earlier stages in the production of the component, when applicable.
- that the inspection and tests were performed in the presence of the Surveyor or in accordance with special agreements, i.e. Alternative Certification Scheme (ACS).

1.5.22 Type approval Certificate

Compliance document issued by the Society by which the Society declares that a product design meets a minimum set of technical requirements.

Figure 1 : Illustrative System Hierarchy



2 Approval of system and components

2.1

2.1.1 System certification

Computer-based systems that are necessary to accomplish vessel-functions of category II or category III (as defined in [3.1.1]) are to be delivered with a vessel-specific Society certificate. The objective of the vessel-specific system certification is to confirm that design and manufacturing of the system has been completed and that the system complies with applicable rules of the Society.

Vessel-specific system certification consist of two main verification activities:

a) Assessment of vessel-specific documentation (see [4.2] and [6])

b) Survey and testing of the system to be delivered to the vessel (see [4.2.7])

The Society may accept Alternative Certification Scheme (ACS) provided that the requirements are met, and that the system is provided with a vessel-specific certificate.

2.1.2 Type approval of computer-based systems

Computer-based systems that are routinely manufactured and include standardized software functions may be type approved in accordance with specified rules of the Society. Hardware is to be documented according to the requirement in [4.2.4].

The type approval consist of two main verification activities:

a) Assessment of type-specific documentation

b) Survey and testing of the standardized functions.

Type approval will normally not yield exemption from vessel-specific system certification since vessel-specific functions, parameter configurations and installation elements demand vessel-specific verification.

3 System categories

3.1 System category definitions

3.1.1

The categorization of a system in the context of this Section is based on the potential severity of the consequences if the system serving the function fails. Tab 2 provides the definitions of the categories.

Table 2 : System categories

Category	Failure Effects	Typical System functionality
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of the vessel and/or a threat to the environment.	Monitoring, informational and administrative functions
II	Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the vessel and/or a threat to the environment.	Vessel alarm, monitoring and control functions which are necessary to maintain the vessel in its normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to dangerous or catastrophic situations for human safety, safety of the vessel and/or a threat to the environment.	• Control functions for maintaining the vessel's propulsion and steering • Vessel safety functions

3.2 Class Societies' scope

3.2.1

Category I systems are normally not subject to verification by the Society, as failure of these systems is not to lead to dangerous situations. However, information pertinent to category I systems is to be required upon request to determine the correct category or ensure that they do not influence the operation of systems in category II and category III.

3.3 System category examples

3.3.1 *(1/1/2025)*

The category of a system is always to be evaluated in the context of the specific vessel in question; thus, the categorization of a system may vary from one vessel to the next. This means that the examples of categories below are given as guidance only. For determining the categorization of systems for a specific vessel, see [4.3.3].

Examples of category I systems:

Fuel monitoring system, maintenance support system, diagnostics and troubleshooting system, closed circuit television, cabin security, entertainment system, fish detection system.

Examples of category II systems:

Fuel oil treatment system, alarm monitoring and safety systems for propulsion and auxiliary machinery.

Examples of category III systems:

Propulsion control system, steering gear control system, electric power system (including power management system), dynamic positioning system (IMO classes 2 and 3).

Note 1: The list of example systems in [3.3.1] is not exhaustive.

4 Requirements on development and certification of computer-based system

4.1 General requirements

4.1.1 Life cycle approach with appropriate standards

Requirement:

A global top-down approach is to be undertaken in the design and development of both hardware and software and the integration in sub-systems, systems, and system of systems, spanning the complete system lifecycle. This approach is to be based on the standards as listed herein or other standards recognized by the Society.

Society's verification:

This is verified by the Society as a part of the quality management system verification described in [4.1.2].

4.1.2 Quality management system

Systems integrators and system suppliers are, in the development of computer-based systems for category II and category III, to comply to a recognised quality standard such as ISO 9001; also incorporating principles of IEC/ISO 90003.

The quality management system is as a minimum to include the topics in Tab 3, applicable for both category II and category III systems.

Table 3 : Quality management system

Area		Role	
N	Topic	System supplier	Systems integrator
1	Responsibilities and competency of the staff	x	x
2	The complete lifecycle of delivered software and of associated hardware	x	x
3	Specific procedure for unique identification of a computer-based system, it's components and versions	x	
4	Creation and update of the vessel's system architecture		x
5	Organization set in place for acquisition of software and related hardware from suppliers	x	x
6	Organization set in place for software code writing and verification	x	
7	Organization set in place for system validation before integration in the vessel	x	
8	Specific procedure for conducting and approving of systems at FAT and SAT	x	x
9	Creation and update of system documentation	x	
10	Specific procedure for software modification and installation on board the vessel, including interactions with shipyard and owner	x	x
11	Specific procedures for verification of software code	x	
12	Procedures for integrating systems with other systems and testing of the system of systems for the vessel	x	x
13	Procedures for managing changes to software and configurations before FAT	x	
14	Procedures for managing and documenting changes to software and configurations after FAT	x	x
15	Checkpoints for the organization's own follow-up of adherence to the quality management system	x	x

Society's verification:

The quality management system may be verified by two alternative means:

a) The Society confirming that the quality management system is certified as compliant to a recognized standard by an organisation with accreditation under a national accreditation scheme.

b) The Society confirming compliance to a standard through a specific assessment of the quality management system. The documentation requirements will be defined per case.

4.2 Requirements on the system supplier

4.2.1 Define and follow a quality plan

Requirement:

The system supplier is to document that the quality management system is applied for the design, construction, delivery, and maintenance of the specific system to be delivered.

All applicable items described in [4.1.2] (for the system supplier role) are to be demonstrated to exist and being followed, as relevant.

Society's verification:

Category I: No documentation required

Category II and III: The quality plan is to be available or submitted for information upon request (I).

4.2.2 Unique identification of systems and software

Requirement:

A method for unique identification of a system, its different software components and different revisions of the same software component is to be applied. The method is to be applied throughout the lifecycle of the system and the software.

See also [7.2] for related technical requirements on the system in question.

The documentation of the method is typically a part of the quality management system, see [4.1.2].

Society's verification:

Category I: Not required

Category II and III: Application of the identification system is verified as a part of the SAT (see [4.3.6]).

4.2.3 System description

Requirement:

The system's specification and design are to be determined and documented in a system description. In addition to serve as a specification for the detailed design and implementation, the purpose of the system description is to document that the entire system-delivery is according to the specifications and in compliance with applicable rules and regulations.

The system description is to contain information of the following:

- Purpose and main functions, including any safety aspects
- System category as defined
- Key performance characteristics
- Compliance with the technical requirements and Society rules
- User interfaces/mimics
- Communication and Interface aspects
  - Identification and description of interfaces to other vessel systems
- Hardware-arrangement related aspects:
  - Network-architecture/topology, including all network components like switches, routers, gateways, firewalls etc.
  - Internal structure with regards to all interfaces and hardware nodes in the system (e.g. operator stations, displays, computers, programmable devices, sensors, actuators, I/O modules etc)
  - I/O allocation (mapping of field devices to channel, communication link, hardware unit, logic function)
  - Power supply arrangement
  - Failure mode description.

Guidance:

The information listed above is in this Section collectively referred to as the system description. It may however be divided into a number of different documents and models.

Society's verification:

Category I: The system description documentation is to upon request be submitted for information (I).

Category II and III: The system description documentation is to be submitted for approval (A).

4.2.4 Environmental compliance of hardware components

Requirement:

Evidence of environmental type testing according to Sec 6 regarding hardware elements included in the system and sub-systems is to be submitted to the Society.

Society's verification:

Category I: This requirement is not mandatory for category I systems. Reference to Type approval certificate or other evidence of type testing is upon request to be submitted for information (I) see [3.2]

Category II and III: Reference to Type approval certificate or other evidence of type testing is to be submitted for information (I).

4.2.5 Software code creation, parameterization, and testing

Requirement:

The software created, changed, or configured for the delivery project is to be developed and have the quality assurance activities assessed according to the selected standard(s) as described in the quality plan.

The quality assurance activities may be performed on several levels of the software-structure and is to include both custom-made software and configured components (e.g. software libraries) as appropriate.

The verification of the software is to as a minimum verify the following aspects based on black-box methods:

- Correctness, completeness and consistency of any parameterization and configuration of software components
- Intended functionality
- Intended robustness

For components in systems of Category II and III, the scope, purpose, and results of all performed reviews, analyses, tests, and other verification activities are to be documented in test reports.

Guidance:

Some of the methods utilized in this activity are sometimes referred to as "software unit test" or "developer test" and may also include verification methods like code-reviews and static- or dynamic code analysis.

Society's verification:

Category I: No documentation required

Category II and III: Software test reports are upon request to be submitted for information (I).

4.2.6 Internal system testing by the System Supplier before delivery

Requirement:

The system is to as far as practicable be tested before delivery. The main purpose of the system test is for the system supplier to verify that the entire system delivery is according to the specifications, approved documentation and in compliance with applicable rules and regulations; and further, that the system is completed for the dliveryx.

The testing is at least to verify the following aspects of the system:

- Functionality
- Effect of faults and failures (including diagnostic functions, detection, alerts response)
- Performance
- Integration between software and hardware components
- Human-machine interfaces
- Interfaces to other systems

Faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response.

Some of the testing may be performed by utilizing simulators and replica hardware.

The test-environment is to be documented, including a description of any simulators, emulators, test-stubs, test-management tools, or other tools affecting the test environment and its limitations.

Test cases and test results are to be documented in test programs and test reports respectively.

Society's verification:

Category I: No documentation required.

Category II and III: Internal system test report is to be made available upon request during SAT (I).

4.2.7 Secure and controlled software installation on the yacht

Requirement:

The initial installation and subsequent updates of the software components of the system is to be done according to a management of change procedure which has been agreed between the system supplier and the systems integrator.

The management of change procedure is to comply with the requirements in [6].

Society's verification:

Category I: Not required.

Category II and III: The management of change procedure is upon request to be submitted for information (I).

4.3 Requirements on the systems integrator

4.3.1 Responsibilities

For the purposes of this Section, the Shipyard is considered as the systems integrator in the development and delivery phase unless another organization or person is explicitly appointed by the Shipyard.

4.3.2 Define and follow a quality plan

Requirement:

The systems integrator is to document that the quality management system is applied for the installation, integration, completion, and maintenance of the systems to be installed on board. All applicable items described in [4.1.2] (for the systems integrator role) are to be demonstrated to exist and being followed, as relevant.

Society's verification:

Category I: No documentation required.

Category II and III: The quality plan is to be made available during survey (at SAT/SOST) or upon request submitted for information (I).

4.3.3 Determining the category of the system in question

Requirement:

For each system delivery to a particular yacht, it is to be decided which category the system falls under based on the failure effects of the system (as defined in [3]). The category for a specific system is to be conveyed to the relevant system supplier. The Society may decide that a risk-assessment is needed to verify the proper system category.

Society's verification:

Category I, II and III: The category for the different systems is upon request to be documented and submitted for approval (A).

4.3.4 Risk assessment of the system

Requirement:

If requested by the Society, a risk assessment of a specific system in context of the specific vessel in question is to be performed and documented in order to determine the applicable category for the system.

Guidance:

IEC/ISO31010 "Risk management - Risk assessment techniques" may be used as guidance in order to determine method of risk assessment.

Society's verification:

Category I, II and III: The risk assessment report is upon request to be submitted for approval (A).

4.3.5 Define the yacht's system-architecture

Requirement:

The system of systems (SoS) is to be specified and documented. This architecture specification provides the basis for category determination and development of the different integrated systems by allocating functionality to individual systems and by identifying the main interfaces between the systems. It is also to serve as a basis for the testing of the integrated systems on the vessel level (see [4.3.7]).

The vessel's system architecture is to at least contain description of:

- Overview of the total systems architecture (the system of systems)
- Each system's purpose and main functionality
- Communication and interface aspects between different systems

Society's verification:

Category I, II and III: The vessel's system architecture is upon request to be submitted for information (I).

4.3.6 System acceptance test (SAT) onboard the yacht

Requirement:

A system acceptance test is to be arranged onboard. The main purpose of the system acceptance test (SAT) is to verify the system functionality, after installation and integration with the applicable machinery/electrical/process systems on board including possible interfaces with other control and monitoring systems.

For each test-case it is to be noted if the test passed or failed, and the test-results are to be documented in a test report. The test report is also to contain a list of the software (including software versions) that were installed in the system when the test was executed.

Society's verification:

Category I: Not required.

Category II and III: The SAT program is to be submitted for approval (A) before the test is executed.

The SAT execution is to be witnessed by the Society.

The SAT report is to be submitted for information (I).

4.3.7 Testing of integrated systems on vessel-level (SOST)

Requirement:

Integration tests are to be conducted after installation and integration of the different systems in its final environment on board. The purpose of the tests is to verify the functionality of the complete installation (system of systems) including all interfaces and inter-dependencies in compliance with requirements and specifications.

The testing is at least to verify the following aspects of the system of systems:

- The overall functionality of the interacting systems as a whole
- Failure response between systems
- Performance
- Human-machine interfaces
- Interfaces between the different systems.

Guidance:

For complex systems there may be a large difference in scope between the "System acceptance test (SAT) onboard the vessel" activity and the SOST, while for some systems the scope may be overlapping or identical. It is possible to combine the two activities into one when the test scope is similar.

Society's verification:

Category I: Not required.

Category II and III: The SOST program is to be submitted for approval (A) before the test is executed.

The SOST execution is to be witnessed by the Society.

The SOST report is to be submitted for information (I).

4.3.8 Change management

Requirement:

The systems integrator is to follow procedures for management of change to the system as described in [6].

Society's verification:

Category I: No documentation requirements.

Category II and III: The management of change procedure is upon request to be submitted for information (I).

5 Requirements on maintenance of computer-based systems

5.1 Requirements on the Systems integrator

5.1.1 Change management

Requirement:

The systems integrator is to ensure that necessary procedures for software and hardware change management exist on board, and that any software modification/upgrade are performed according to the procedure(s). For details about change management please see [6].

Changes to computer-based systems in the operational phase are to be recorded.

The records are to contain information about the relevant software versions and other relevant information as described in [6.11].

Society’s verification:

Category I: No documentation requirements

Category II and III: See [6.12].

5.2 Requirements on the System Supplier

5.2.1 Change management

Requirement:

The system supplier is to follow procedures for maintenance of the system including procedures for management of change as described in [6].

Society’s verification:

Category I: No documentation requirements

Category II and III: See [6.12].

5.2.2 Testing of changes before installation onboard

Requirement:

The system supplier is to make sure that the planned changes to a system have passed relevant in-house tests before the change is made to systems on board.

Society’s verification:

Category I: No documentation requirements

Category II and III: See [6.12].

6 Management of change

6.1 General

6.1.1

This Article provides requirements for the management of change throughout the lifecycle of a computer-based system. Different procedures for the management of change may be defined for specific phases in a system’s lifecycle as the different phases typically involve different stakeholders. The Society’s verification is described in [6.12].

6.2 Documented change management procedures

6.2.1

Requirement:

The organization in question is to have defined and documented change management procedures applicable for the computer-based system in question covering both hardware and software. After SAT, the system supplier is to manage all changes to the system in accordance with the procedure. Examples could be qualification of new versions of acquired software, new hardware, modified control logic, changes to configurable parameters.

The procedure(s) is at least to describe the activities listed in [6.3] through [6.11]. The outcome of the impact analysis in [6.8] will determine to what extent the activities in [6.3] to [6.12] are to be performed. Change records (described in [6.11]) are always to be produced.

6.3 Agreement between relevant stakeholders

6.3.1

Requirement:

The management of change process is to be coordinated and agreed between the relevant stakeholders along the different stages of the lifecycle of the computer-based system.

Guidance:

Typically, the management of change address at least three different stages:

- Development and internal verification before SAT; involving the system supplier and sub-suppliers.
- From SAT to handover of the vessel to the owner; involving the system supplier, the systems integrator, the Society, and the owner.
- In operation; involving the system supplier, service suppliers, the owner, and the Society

6.4 Approved software shall be under change management

6.4.1

Requirement:

If changes are required to system after it has been approved by applicable stakeholders (typically the systems integrator and the Society at SAT) the modifications are to follow defined change management procedures.

6.5 Unique identification of system and software versions

6.5.1

Requirement:

The system supplier is to make sure that each system and software version is uniquely identifiable, see [4.2.2].

6.6 Handling of software master files

6.6.1

Requirement:

There are to be defined mechanisms for handling of the files that constitutes the master-files for a software component. Personnel authorities are to be clearly defined along with the tools and mechanisms used to ensure the integrity of the master files.

6.7 Backup and restoration of onboard software

6.7.1

Requirement:

It is to be clearly defined how to perform backup and restoration of the software components of a computer-based system onboard.

6.8 Impact analysis before change is made

6.8.1

Requirement:

Before a change to the system is made, an impact analysis is to be performed in order to:

- Determine the criticality of the change.
- Determine the impact on existing documentation.
- Determine the needed verification and test activities.
- Determine the need to inform other stakeholders about the change.
- Determine the need to obtain approval from other stakeholders (e.g. Society and or Owner) before the change is made.

6.9 Roll-back in case of failed software changes

6.9.1

Requirement:

When maintenance includes installation of new versions of the software in the system, it is to be possible to perform a rollback of the software to the previous installed version with the purpose of returning the system to a known, stable state.

Roll-backs are to be documented and analysed to find and eliminate the root cause.

6.10 Verification and validation of system changes

6.10.1

Requirement:

To the largest degree practically possible, modifications are to be verified before being installed onboard.

After installation, the modification(s) is to be verified onboard according to a documented verification program containing:

- Verification that the new functionalities and/or improvements have had the intended effect.
- Regression test to verify that the modification has not had any negative effects on functionality or capabilities that was not expected to be affected.

6.11 Change records

6.11.1

Changes to systems and software are to be documented in change records to allow for visibility and traceability of the changes. The change records is to contain at least the following items:

- The purpose for a change
- A description of the changes and modifications
- The main conclusions from the impact analysis (see [6.8])
- The identity and version of any new system or software version(s) (see [6.5])
- Test reports or tests summaries (see [6.10])

Documentation of the changes to software may be recorded in the planned maintenance system (PMS), in a software registry or equivalent.

6.12 Verification of change management by the Society

6.12.1 In operation (yacht in service) phase

The verification by the Society regarding the management of change in operation is generally performed during the annual survey of the vessel. Procedures for management of change and relevant change records (see [6.11]) are to be made available at the time of survey.

In the cases where the change requires approval from the Society up front, the relevant procedures and documentation for the change in question may be verified at that time.

7 Technical requirements on computer-based systems

7.1 General

7.1.1

The Articles below contain technical requirements on computer-based systems. The compliance to these requirements are to be documented in the design documentation (see [4.2.3]) and verified through the verification activities described in this Section.

7.2 Reporting of system and software identification and version

7.2.1 System identification

The system is to provide means to identify its name, version, identifier, and manufacturer. It is recommended that the system can automatically report the status of its software to a yacht software logging system (SSLS) as specified in the international standard ISO 24060.

7.3 Data links

7.3.1 General requirements for category II and III systems

Loss of a data link is to be specifically addressed in risk assessment analysis/FMEA. See [4.2.3].

a) A single failure in data link is not to cause loss of vessel- functions of category III. Any effect of such failures is to meet the principle of fail-to-safe for the vessel-function(s) being served.

b) For vessel-functions of category II and III, any loss of functionality in the remote control system is to be compensated for by local/manual means.

c) The data link is to have means to prevent or cope with excessive communication rates.

d) Data links are to be self-checking, detecting failures or performance issues on the link itself and data communication failures on nodes connected to the link.

e) Detected failures are to initiate an alarm.

7.3.2 Specific requirements for wireless data links

a) Category III systems are not to use wireless data links unless specifically considered by the Society on the basis of an engineering analysis carried out in accordance with an International or National Standard acceptable to the Society.

Other categories of systems may use wireless data links with the following requirements:

b) Recognised international wireless communication system protocols are to be employed, incorporating:

1) Message integrity. Fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message.

2) Configuration and device authentication. It is only to permit connection of devices that are included in the system design.

3) Message encryption. Protection of the confidentiality and or criticality of the data content.

4) Security management. Protection of network assets, prevention of unauthorized access to network assets.

c) The internal wireless system within the vessel is to comply with the radio frequency and power level requirements of International Telecommunication Union and flag state requirements.

d) Consideration should be given to system operation in the event of port state and local regulations that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication link due to frequency and power level restrictions.

e) For wireless data communication equipment, tests during harbour and sea trials are to be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not self-fail as a result of electromagnetic interference during expected operating conditions.

7.4 Verification of technical requirements by the Society

7.4.1

The implementation of the technical requirements provided in [7] is verified by the Society as part of the system description ([4.2.3]) and SAT ([4.3.6]) described above.

8 Summary of documentation submittal

8.1

8.1.1

Tab 4 and Tab 5 summarise the documentation to be submitted to the Society.

8.1.2

The Society reserves the right to request the submission of additional documents if it is deemed necessary for the evaluation of the system, equipment or components.

Table 4 : Summary of documentation submittal by the system supplier

Item		Responsible role	System Category		
Paragraph reference	Document		I	II	III
[4.2.1]	Quality plan	System supplier	- (2)	I (1)	I (1)
[4.2.3]	System description	System supplier	I (1)	A	A
[4.2.4]	Environmental compliance	System supplier	I (1)	I	I

Note 1:
A = Submitted for approval I = Provided (for information)
(1) Upon request from the Society
(2) "-" means: No requirement

Item		Responsible role	System Category		
Paragraph reference	Document		I	II	III
[4.2.5]	Software test reports	System supplier	-	I (1)	I (1)
[4.2.6]	System test report	System supplier	-	I (1)	I (1)
[4.2.7]	Management of change procedure	System supplier	-	I (1)	I (1)

Note 1:
A = Submitted for approval I = Provided (for information)
(1) Upon request from the Society
(2) "-" means: No requirement

Table 5 : Summary of documentation submittal by the system integrator

Item		Responsible role	System Category		
Paragraph reference	Document		I	II	III
[4.3.2]	Quality plan	Systems integrator	- (2)	I (1)	I (1)
[4.3.3]	List of system categorizations	Systems integrator	A (1)	A (1)	A (1)
[4.3.4]	Risk assessment report	Systems integrator	A (1)	A (1)	A (1)
[4.3.5]	Vessel's system architecture	Systems integrator	I (1)	I (1)	I (1)
[4.3.6]	SAT program	Systems integrator	-	A	A
[4.3.6]	SAT report	Systems integrator	-	I	I
[4.3.7]	SOST program	Systems integrator	-	A	A
[4.3.7]	SOST report	Systems integrator	-	I	I
[4.3.8]	Change management procedure for software	Systems integrator	-	I (1)	I (1)

Note 1:
A = Submitted for approval I = Provided (for information)
(1) Upon request from the Society
(2) "-" means: No requirement

9 Summary of test witnessing and survey

9.1

9.1.1

Tab 6 summarises the activities that are to be witnessed or surveyed by the Society. The responsible role is to facilitate the activity.

Table 6 : Summary of test witnessing and survey

Item		Responsible role	System Category		
Paragraph reference	Activity		I	II	III
[4.3.6]	SAT witnessing	System integrator	-	x	x
[4.3.7]	SOST witnessing	System integrator	-	x	x
[6.12]	Verification of changes	System integrator	-	x	x

Note 1:
(1) Witnessing required
(2) "-" means: No requirement

SECTION 4 CONSTRUCTIONAL REQUIREMENTS

1 General

1.1 Construction

1.1.1 Automation systems are to be so constructed as:

- to withstand the environmental conditions, as defined in Ch 2, Sec 2, [1], in which they operate
- to have necessary facilities for maintenance work.

1.2 Materials

1.2.1 Materials are generally to be of the flame-retardant type.

1.2.2 Connectors are to be able to withstand standard vibrations, mechanical constraints and corrosion conditions as given in Sec 6.

1.3 Component design

1.3.1 Automation components are to be designed to simplify maintenance operations. They are to be so constructed as to have:

- easy identification of failures
- easy access to replaceable parts
- easy installation and safe handling in the event of replacement of parts (plug and play principle) without impairing the operational capability of the system, as far as practicable
- facility for adjustment of set points or calibration
- test point facilities, to verify the proper operation of components.

1.4 Environmental and supply conditions

1.4.1 The environmental and supply conditions are specified in Sec 1. Specific environmental conditions are to be considered for air temperature and humidity, vibrations, corrosion from chemicals and mechanical or biological attacks.

2 Electrical and/or electronic systems

2.1 General

2.1.1 Electrical and electronic equipment is to comply with the requirements of Chapter 2 and Chapter 3.

2.1.2 A separation is to be done between any electrical components and liquids, if they are in a same enclosure. Necessary drainage will be provided where liquids are likely to leak.

2.1.3 When plug-in connectors or plug-in elements are used, their contacts are not to be exposed to excessive mechanical loads. They are to be provided with a locking device.

2.1.4 All replaceable parts are to be so arranged that it is not possible to connect them incorrectly or to use incorrect replacements. Where this not practicable, the replacement parts as well as the associated connecting devices are to be clearly identified. In particular, all connection terminals are to be properly tagged. When replacement cannot be carried out with the system on, a warning sign is to be provided.

2.1.5 Forced cooling systems are to be avoided. Where forced cooling is installed, an alarm is to be provided in the event of failure of the cooling system.

2.1.6 The interface connection is to be so designed to receive the cables required. The cables are to be chosen according to Ch 2, Sec 3.

2.2 Electronic system

2.2.1 Printed circuit boards are to be so designed that they are properly protected against the normal aggression expected in their environment.

2.2.2 Electronic systems are to be constructed taking account of electromagnetic interferences.

Special precautions are to be taken for:

- measuring elements such as the analogue amplifier or analog/digital converter; and
- connecting different systems having different ground references.

2.2.3 The components of electronic systems (printed circuit board, electronic components) are to be clearly identifiable with reference to the relevant documentation.

2.2.4 Where adjustable set points are available, they are to be readily identifiable and suitable means are to be provided to protect them against changes due to vibrations and uncontrolled access.

2.2.5 The choice of electronic components is to be made according to the normal environmental conditions, in particular the temperature rating.

2.2.6 All stages of fabrication of printed circuit boards are to be subjected to quality control. Evidence of this control is to be documented.

2.2.7 Burn-in tests or equivalent tests are to be performed.

2.2.8 The programmable components are to be clearly tagged with the program date and reference.

Components are to be protected against outside alteration when loaded.

2.3 Electrical system

2.3.1 Cables and insulated conductors used for internal wiring are to be at least of the flame-retardant type, and are to comply with the requirements in Chapter 2.

2.3.2 If specific products (e.g. oil) are likely to come into contact with wire insulation, the latter is to be resistant to such products or properly shielded from them, and to comply with the requirements in Chapter 2.

3 Pneumatic systems

3.1

3.1.1 Pneumatic automation systems are to comply with Ch 1, Sec 10, [13].

3.1.2 Pneumatic circuits of automation systems are to be independent of any other pneumatic circuit on board.

4 Hydraulic systems

4.1

4.1.1 Hydraulic automation systems are to comply with Ch 1, Sec 10, [13].

4.1.2 Suitable filtering devices are to be incorporated into the hydraulic circuits.

4.1.3 Hydraulic circuits of automation systems are to be independent of any other hydraulic circuit on board.

5 Automation consoles

5.1 General

5.1.1 Automation consoles are to be designed on ergonomic principles. Handrails are to be fitted for safe operation of the console.

5.2 Indicating instruments

5.2.1 The operator is to receive feed back information on the effects of his orders.

5.2.2 Indicating instruments and controls are to be arranged according to the logic of the system in control. In addition, the operating movement and the resulting movement of the indicating instrument are to be consistent with each other.

5.2.3 The instruments are to be clearly labelled. When installed in the wheelhouse, all lighted instruments of consoles are to be dimmable, where necessary.

5.3 VDU's and keyboards

5.3.1 VDU's in consoles are to be located so as to be easily readable from the normal position of the operator. The environmental lighting is not to create any reflection which makes reading difficult.

5.3.2 The keyboard is to be located to give easy access from the normal position of the operator. Special precautions are to be taken to avoid inadvertent operation of the keyboard.

SECTION 5 INSTALLATION REQUIREMENTS

1 General

1.1

1.1.1 Automation systems are to be installed taking into account:

- the maintenance requirements (test and replacement of systems or components)
- the influence of EMI. The IEC 60533 standard is to be taken as guidance
- the environmental conditions corresponding to the location in accordance with Ch 2, Sec 1 and Ch 2, Sec 3, [6].

1.1.2 Control stations are to be arranged for the convenience of the operator.

1.1.3 Automation components are to be properly fitted. Screws and nuts are to be locked, where necessary.

2 Sensors and components

2.1 General

2.1.1 The location and selection of the sensor is to be done so as to measure the actual value of the parameter. Temperature, vibration and EMI levels are to be taken into account. When this is not possible, the sensor is to be designed to withstand the local environment.

2.1.2 The enclosure of the sensor and the cable entry are to be appropriate to the space in which they are located.

2.1.3 Means are to be provided for testing, calibration and replacement of automation components. Such means are to be designed, as far as practicable, so as to avoid perturbation of the normal operation of the system.

2.1.4 A tag number is to identify automation components and is to be clearly marked and attached to the component. These tag numbers are to be collected on the instrument list mentioned in Sec 1, Tab 1.

2.1.5 Electrical connections are to be arranged for easy replacement and testing of sensors and components. They are to be clearly marked.

2.1.6 Low level signal sensors are to be avoided. When installed they are to be located as close as possible to amplifiers, so as to avoid external influences. Failing this, the wiring is to be provided with suitable EMI protection and temperature correction.

2.2 Temperature elements

2.2.1 Temperature sensors, thermostats or thermometers are to be installed in a thermowell of suitable material, to permit easy replacement and functional testing. The thermowell is not to significantly modify the response time of the whole element.

2.3 Pressure elements

2.3.1 Three-way valves or other suitable arrangements are to be installed to permit functional testing of pressure elements, such as pressure sensors, pressure switches or pressure gauges, without stopping the installation.

2.3.2 In specific applications, where high pulsations of pressure are likely to occur, a damping element, such as a capillary tube or equivalent, is to be installed.

2.4 Level switches

2.4.1 Level switches fitted to flammable oil tanks, or similar installations, are to be installed so as to reduce the risk of fire.

3 Cables

3.1 Installation

3.1.1 Cables are to be installed according to the requirements in Ch 2, Sec 12, [7].

3.1.2 Suitable installation features such as screening and/or twisted pairs and/or separation between signal and other cables are to be provided in order to avoid possible interference on control and instrumentation cables.

3.1.3 Specific transmission cables (coaxial cables, twisted pairs, etc.) are to be routed in specific cable-ways and mechanically protected to avoid loss of any important transmitted data. Where there is a high risk of mechanical damage, the cables are to be protected with pipes or equivalent.

3.1.4 The cable bend radius is to be in accordance with the requirements of Ch 2, Sec 12, [7.2].

For mineral insulated cables, coaxial cables or fibre optic cables, whose characteristics may be modified, special precautions are to be taken according to the manufacturer's instructions.

3.2 Cable terminations

3.2.1 Cable terminations are to be arranged according to the requirements in Chapter 2. Particular attention is to be paid to the connections of cable shields. Shields are to be connected only at the sensor end when the sensor is earthed, and only at the processor end when the sensor is floating.

3.2.2 Cable terminations are to be able to withstand the identified environmental conditions (shocks, vibrations, salt mist, humidity, etc.).

3.2.3 Terminations of all special cables such as mineral insulated cables, coaxial cables or fibre optic cables are to be arranged according to the manufacturer's instructions.

4 Pipes

4.1

4.1.1 For installation of piping circuits used for automation purposes, see the requirements in Ch 1, Sec 10.

4.1.2 As far as practicable, piping containing liquids is not to be installed in or adjacent to electrical enclosures (see Sec 4, [2.1.2]).

4.1.3 Hydraulic and pneumatic piping for automation systems is to be marked to indicate its function.

5 Automation consoles

5.1 General

5.1.1 Consoles or control panels are to be located so as to enable a good view of the process under control, as far as practicable. Instruments are to be clearly readable in the ambient lighting.

5.1.2 The location is to be such as to allow easy access for maintenance operations.

SECTION 6 TESTING

1 General

1.1 Commissioning

1.1.1 Automation systems are to be tested for type approval, acceptance or commissioning, when required. Tests are to be carried out under the supervision of a Surveyor of the Society.

1.1.2 The type testing conditions for electrical, control and instrumentation equipment, computers and peripherals are described in [2].

1.1.3 Automation systems are to be inspected when installed on board and prior to sea trials, to verify their performance and adaptation on site, according to [4].

2 Type approval

2.1 General

2.1.1

This test specification for type approval is applicable, but not confined, to electrical, electronic and programmable equipment intended for (see Note 1a)):

- control, monitoring, alarm and protection systems for use in s
- internal communication.

Note 1:

a) These test requirements are harmonised with IEC 60092-504 “Electrical Installations in s -Part 504: Special features - Control and Instrumentation” and IEC 60533 “Electrical and electronic installations in s - Electromagnetic compatibility”. Electrical and electronic equipment on board s, required neither by the Rules nor by International Conventions, liable to cause electromagnetic disturbance are to be of type which fulfill the test requirements of test specification items 19 and 20 of Tab 1.

b) Functional test, as used in Tab 1, is a simplified test sufficient to verify that the equipment under test (EUT) has not suffered any deterioration caused by the individual environmental tests and not a complete performance test as required in item 2 of Tab 1.

2.1.2 The necessary documents to be submitted, prior to type testing, are listed in Sec 1, [2.4.1]. The type approval of automation systems refers to hardware type approval or software type approval, as applicable.

2.2 Hardware type approval

2.2.1

These tests are to demonstrate the ability of the equipment to function as intended under the specified testing conditions.

The extent of the testing, i.e. the selection and sequence of tests and the number of pieces to be tested is to be determined upon examination and evaluation of the equipment or component subject to testing giving due regard to its intended use.

Equipment is to be tested in its normal position unless otherwise specified in the test specification.

The relevant tests are listed in Tab 1.

2.2.2 The following additional tests may be required, depending on particular manufacturing or operational conditions:

- mechanical endurance test
- temperature shock test (e.g. 12 shocks on exhaust gas temperature sensors from 20°C ± 5°C to maximum temperature of the range)
- immersion test
- oil resistance test
- shock test.

The test procedure is to be defined with the Society in each case.

Table 1 : Type tests

No.	Test	Procedure **(1)**	Test parameters	Other information
1	Visual inspection			• conformance to drawings, design data.
2	Performance test	Manufacturer performance test programme based upon specification and relevant Rule requirements. When the EUT is required to comply with an international performance standard, e.g. protection relays, verification of requirements in the standard are to be part of the performance testing required in this initial test and subsequent performance tests after environmental testing where required in this Tab 1.	• standard atmosphere condition • temperature: 25°C ± 10°C • relative humidity: 60% ± 30% • air pressure: 96 KPa ±10 KPa	• confirmation that operation is in accordance with the requirements specified for particular system or equipment • checking of self-monitoring features • checking of specified protection against an access to the memory • checking against effect an erroneous use of control elements in the case of computer systems
3	External power supply failure		• 3 interruptions during 5 minutes • switching- off time 30 s each case	• The time of 5 minutes may be exceeded if the equipment under test needs a longer time for start up, e.g. booting sequence • For equipment which requires booting, one additional power supply interruption during booting to be performed Verification of: • equipment behaviour upon loss and restoration of supply; • possible corruption of programme or data held in programmable electronic systems, where applicable.

No.	Test	Procedure **(1)**	Test parameters	Other information
4	Power supply variations a) Electric		AC SUPPLY Combinati on Voltage variation permanent Frequency variation permanent 1 2 + 6% + 5% 3 + 6% – 5% 4 – 10% – 5% – 10% + 5% voltage transient frequency transient 1,5 s 5 s 5 % % 6 + 20% + 10% – 20% – 10%	
			DC SUPPLY Voltage tolerance continuous: ± 10% Voltage cyclic variation: 5% Voltage ripple: 10% Electric battery supply: • +30% to –25% for equipment connected to charging battery or as determined by the charging/discharging characteristics, including ripple voltage from the charging device; • +20% to –25% for equipment not connected to the battery during charging	
	b) Pneumatic and hydraulic		Pressure: ± 20% Duration: 15 minutes	
5	Dry heat (see **(2)**)	IEC 60068-2-2 Test Bb for non-heat dissipating equipment	• Temperature: 55°C ± 2°C Duration: 16 hours, or • Temperature: 70°C ± 2°C Duration: 16 hours	• equipment operating during conditioning and testing • functional test (see [2.1.1] Note 1b)) during the last hour at the test temperature • for equipment specified for increased temperature the dry heat test is to be conducted at the agreed test temperature and duration.
		IEC 60068-2-2 Test Be for heat dissipating equipment	• Temperature: 55°C ± 2°C Duration: 16 hours, or • Temperature: 70°C ± 2°C Duration: 16 hours	• equipment operating during conditioning and testing with cooling system on if provided • functional test (see [2.1.1] Note 1b)) during the last hour at the test temperature • for equipment specified for increased temperature the dry heat test is to be conducted at the agreed test temperature and duration

No.	Test	Procedure **(1)**	Test parameters	Other information
6	Damp heat	IEC 60068-2-30 Test D_b	Temperature: 55°C Humidity: 95% Duration: 2 cycles 2 x (12 + 12 hours)	• measurement of insulation resistance before test • the test is to start with 25°C ± 3°C and at least 95% humidity • equipment operating during the complete first cycle and switched off during second cycle except for functional test • functional test during the first 2 hours of the first cycle at the test temperature and during the last 2 hours of the second cycle at the test temperature; duration of the second cycle can be extended due to more convenient management of the functional test • recovery at standard atmosphere conditions • insulation resistance measurements and performance test
7	Vibration	IEC 60068-2-6 Test F_c	• 2 Hz ± 3/0 Hz to 13,2 Hz – amplitude: ± 1mm • 13,2 Hz to 100 Hz – acceleration: ± 0,7 g For severe vibration conditions such as, e. g., on diesel engines, air compressors, etc.: • 2,0 Hz to 25 Hz – amplitude: ± 1,6 mm • 25 Hz to 100 Hz – acceleration: ± 4,0 g Note: More severe conditions may exist for example on exhaust manifolds or fuel oil injection systems of diesel engines. For equipment specified for increased vibration levels the vibration test is to be conducted at the agreed vibration level, frequency range and duration. Values may be required to be in these cases 40 Hz to 2000 Hz - acceleration: ± 10,0 g at 600°C,duration 90 min.	• duration in case of no resonance condition 90 minutes at 30 Hz; • duration at each resonance frequency at which Q ≥ 2 is recorded - 90 minutes; • during the vibration test, functional tests are to be carried out; • tests to be carried out in three mutually perpendicular planes; • it is recommended as a guidance that Q does not exceed 5. • where sweep test is to be carried out instead of the discrete frequency test and a number of resonant frequencies are detected close to each other, duration of the test is to be 120 min. Sweep over a restricted frequency range between 0,8 and 1,2 times the critical frequencies can be used where appropriate. Note: Critical frequency is a frequency at which the equipment being tested may exhibit: • malfunction and/or performance deterioration • mechanical resonances and/or other response effects occur, e.g. chatter

No.	Test	Procedure (1)	Test parameters	Other information
8	Inclination	IEC 60092-504	Static 22,5°	a) inclined to the vertical at an angle of at least 22,5° b) inclined to at least 22,5° on the other side of the vertical and in the same plane as in (a) c) inclined to the vertical at an angle of at least 22,5° in plane at right angles to that used in (a) d) inclined to at least 22,5° on the other side of the vertical and in the same plane as in (c). Note: The period of testing in each position should be sufficient to fully evaluate the behaviour of the equipment.
			Dynamic 22,5°	Using the directions defined in a) to d) above, the equipment is to be rolled to an angle of 22,5° each side of the vertical with a period of 10 seconds. The test in each direction is to be carried out for not less than 15 minutes. On s for the carriage of liquified gases and chemicals, the emergency power supply is to remain operational with the flooded up to a maximum final athwart inclination of 30°. Note: These inclination tests are normally not required for equipment with no moving parts
9	Insulation resistance	Rated supply voltage voltage U_n(V) (V) / Test voltage D.C. $U_n \leq 65$ / 2 x U_n min. 24 $U_n > 65$ / 500	Minimum insulation resistance before test / after test 10 MW / 1,0 MW 100 MW / 10 MW	For high voltage equipment, reference is made to Ch 2, Sec 13. • insulation resistance test is to be carried out before and after: damp heat test, cold test and salt mist test, high voltage test; • between all circuits and earth; and where appropriate • between the phases. Note: Certain components e.g. for EMC protection may be required to be disconnected for this test.

No.	Test	Procedure **(1)**	Test parameters	Other information
10	High voltage	Rated voltage U_n (V) Up to 65 66 to 250 251 to 500 501 to 690	Test voltage (V) (A.C. voltage 50 or 60Hz) 2 x U_n + 500 1500 2000 2500	For high voltage equipment, reference is made to Ch 2, Sec 13. • separate circuits are to be tested against each other and all circuits connected with each other tested against earth; • printed circuits with electronic components may be removed during the test; • period of application of the test voltage: 1 minute
11	Cold	IEC 60068-2-1	• Temperature: +5°C ± 3°C Duration: 2 hours, or • Temperature: –25°C ± 3°C Duration: 2 hours (see **(3)**)	• initial measurement of insulation resistance; • equipment not operating during conditioning and testing except for operational test; • operational test during the last hour at the test temperature; • insulation resistance measurement and the operational test after recovery
12	Salt mist	IEC 60068-2-52 Test Kb	Four spraying periods with a storage of seven days after each.	• initial measurement of insulation resistance and initial functional test • equipment not operating during conditioning • functional test on the 7th day of each storage period • insulation resistance measurement and performance test 4 to 6h after recovery (see **(4)**) • on completion of exposure, the equipment shall be examined to verify that deterioration or corrosion (if any) is superficial in nature
13	Electrostatic discharge	IEC 61000-4-2	Contact discharge: 6 kV Air discharge: 2kV, 4kV, 8 kV Interval between single discharges: 1 s. No. of pulses: 10 per polarity According to test level 3	• to simulate electrostatic discharge as may occur when persons touch the appliance • the test is to be confined to the points and surfaces that can normally be reached by the operator • performance Criterion B (see **(5)**)

No.	Test	Procedure (1)	Test parameters	Other information
14	Electromagnetic field	IEC 61000-4-3	Frequency range: 80 MHz 6 GHz Modulation**: 80% AM at 1000Hz Field strength: 10V/m Frequency sweep rate: £ 1,5.10^{-3} decades/s (or 1% / 3 s) According to test level 3	• to simulate electromagnetic fields radiated by different transmitters • the test is to be confined to the appliances exposed to direct radiation by transmitters at their place of installation • performance criterion A (see **(6)**). ** If, for tests of equipment, an input signal with a modulation frequency of 1000 Hz is necessary, a modulation frequency of 400 Hz may be chosen • If an equipment is intended to receive radio signals for the purpose of radio communication (e.g. wi-fi router, remote radio controller), then the immunity limits at its communication frequency do not apply, subject to the provisions in Sec 3, [4.2].
15	Conducted low frequency		A.C.: • Frequency range: rated frequency to 200th harmonic • Test voltage (rms): 10% of supply to 15th harmonic reducing to 1% at 100th harmonic and maintain this level to the 200th harmonic, min 3 V rms Max 2 W D.C.: • Frequency range: 50 Hz - 10 kHz • Test voltage (rms) :10% of supply max. 2 W	• to simulate distortions in the power supply system generated for instance, by electronic consumers and coupled in as harmonics • performance criterion A (see **(6)**) • See Figure in Notes in this Table • to keep max. 2W, the voltage of the test signal may be lower.
16	Conducted Radio Frequency	IEC 61000-4-6	AC, DC, I/O ports and signal/control lines: Frequency range: 150 kHz - 80 MHz Amplitude: 3 V rms (see **(7)**) Modulation***: 80% AM at 1000 Hz Frequency sweep range: $\leq$1,5.10^{-3} decades/s (or 1% / 3sec.) According to test level 2	• Equipment design and the choice of materials is to simulate electromagnetic fields coupled as high frequency into the test specimen via the connecting lines • performance criterion A (see **(6)**). *** If, for tests of equipment, an input signal with a modulation frequency of 1000 Hz is necessary, a modulation frequency of 400 Hz may be chosen
17	Electrical Fast Transients / Burst	IEC 61000-4-4	Single pulse time: 5ns (between 10% and 90% value) Single pulse width: 50 ns (50% value) Amplitude (peak): 2 kV line on power supply port/earth; 1 kV on I/O data control and communication ports (coupling clamp) Pulse period: 300 ms Burst duration: 15 ms Duration/polarity: 5 min According to test level 3	• arcs generated when actuating electrical contacts • interface effect occurring on the power supply, as well as at the external wiring of the test specimen • performance criterion B (see **(5)**)

No.	Test	Procedure **(1)**	Test parameters	Other information
18	Surge	IEC 61000-4-5	Test applicable to AC and DC power ports Open-circuit voltage: Pulse rise time: 1,2 μs ((front time) Pulse width: 50 μs (time to half value) Amplitude (peak) : 1 kV line/earth; 0,5 kV line/line Short-circuit current: Pulse rise time: 8 μs (front time) Pulse width: 20 μs (time to half value) Repetition rate: > 1 pulse/min No of pulses: 5 per polarity Application: continuous According to test level 2	• interference generated for instance, by switching "ON" or "OFF" high power inductive consumers • test procedure in accordance with figure 10 of the standard for equipment where power and signal lines are identical • performance criterion B (see **(5)**)
19	Radiated Emission	CISPR 16-2-3 IEC 60945 for 156-165 MHz	Limits below 1000 MHz For equipment installed in the bridge and deck zone: Frequency range: — Quasi peak limits: 0,15 - 0,30 MHz — 80 - 52 dBμV/m 0,30 - 30 MHz — 52 - 34 dBμV/m 30 - 1000 MHz — 54 dBμV/m except for: 156 - 165 MHz — 24 dBμV/m For equipment installed in the general power distribution zone: Frequency range: — Quasi peak limits: 0,15 - 30 MHz — 80 - 50 dBμV/m 30 - 100 MHz — 60 - 54 dBμV/m 100 - 1000 MHz — 54 dBμV/m except for: 156 - 165 MHz — 24 dBμV/m Limits above 1000 MHz Frequency range: Average limit: 1000 - 6000 MHz 54 dBmV/m	• procedure in accordance with the standard but distance 3 m between equipment and antenna • for the frequency band 156 MHz to 165 MHz the measurement is to be repeated with a receiver bandwidth of 9 kHz (as per IEC 60945) • alternatively the radiation limit at a distance of 3 m from the enclosure port over the frequency 156 MHz to 165 MHz is to be 30 dB micro-V/m peak (as per IEC 60945). • procedure in accordance with the standard (distance 3 m between equipment and antenna) • equipment intended to transmit radio signals for the purpose of radio communication (e.g. wi-fi router, remote radio controller) may be exempted from limit, within its communication frequency range, subject to the provisions in Sec 3, [4.2].
20	Conducted Emission	CISPR 16-2-1	Test applicable to AC and DC power ports For equipment installed in the bridge and deck zone: Frequency range: — Limits: 10 - 150 kHz — 96 - 50 dBμV 150 - 350 kHz — 60 - 50 dBμV 0,35 - 30 MHz — 50 dBμV For equipment installed in the general power distribution zone: Frequency range: — Limits: 10 - 150 kHz — 120 - 69 dBμV 150 - 500 kHz — 79 dBμV 0,5 - 30 MHz — 73 dBμV	

No.	Test	Procedure (1)	Test parameters	Other information
21	Flame retardant	IEC 60092-101 or IEC 60695-11-5	Flame application: 5 times 15 s each Interval between each application: 15 s or one time 30 s. Test criteria based upon application. The test is performed with the EUT or housing of the EUT applying needle-flame test method.	• the burnt out or damaged part of the specimen by not more than 60mm long • no flame, no incandescence or in the event of a flame or incandescence being present, it is to extinguish itself within 30 s of the removal of the needle flame without full combustion of the test specimen • any dripping material is to extinguish itself in such a way as not to ignite a wrapping tissue. The drip height is 200 mm ± 5 mm.

(1) Column 3 indicates the testing procedure which is normally to be applied. However, equivalent testing procedure may be accepted by the Society provided that what required in the other columns is fulfilled. The latest edition of the normative reference applies.

(2) Dry heat at 70 °C is to be carried out to automation, control and instrumentation equipment subject to high degree of heat, for example mounted in consoles, housings, etc. together with other heat dissipating power equipment.

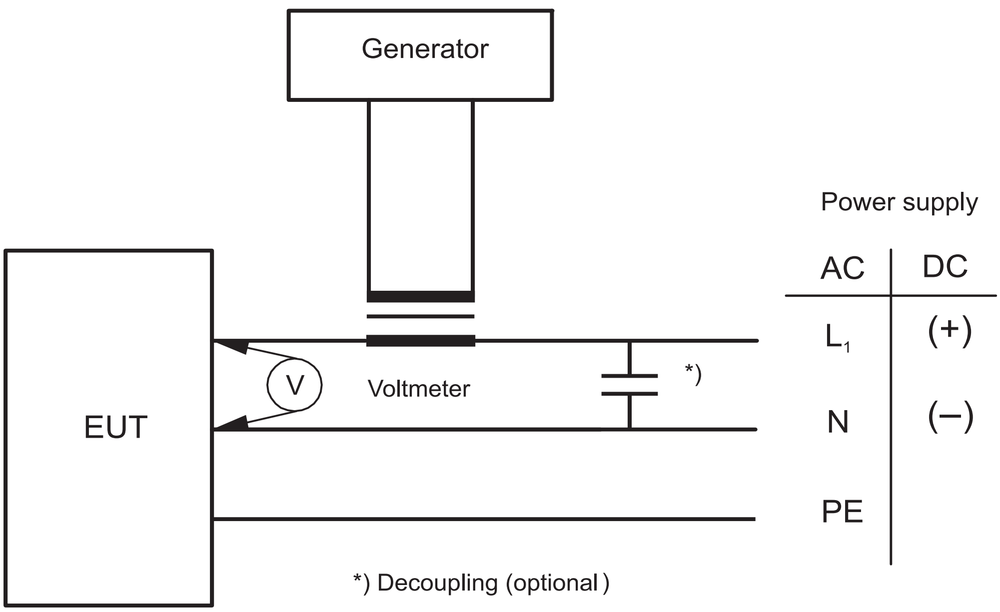
(3) For equipment installed in non-weather protected locations or cold locations test is to be carried out at –25°C.

(4) Salt mist test is to be carried out for equipment installed in weather exposed areas.

(5) Performance Criterion B: (for transient phenomena): the EUT is to continue to operate as intended after the tests. No degradation of performance or loss of function is allowed as defined in the technical specification published by the Manufacturer. During the test, degradation or loss of function or performance which is self recoverable is however allowed but no change of actual operating state or stored data is allowed.

(6) Performance Criterion A (for continuous phenomena): the Equipment Under Test is to continue to operate as intended during and after the test. No degradation of performance or loss is allowed as defined in relevant equipment standard and the technical specification published by the Manufacturer.

(7) For equipment installed on the bridge and deck zone, the test levels are to be increased to 10V rms for spot frequencies in accordance with IEC 60945 at 2; 3; 4; 6.2; 8.2; 12.6; 16.5; 18.8; 22; 25 MHz.



2.3 Software type approval

2.3.1 Software type approval consists of evaluation of the development quality and verification of test results.

Documents in accordance with Sec 1, Tab 2 are required to demonstrate the development quality.

Repetition of unit tests, integration tests or validation tests is required to verify the consistency of test results.

Certificate may be issued at the request of the manufacturer when approval is granted.

2.3.2 For programmable electronic systems, as a guidance, the documents to be submitted for information are listed in Tab 2.

2.3.3 The software type approval applies only to basic software of the programmable electronic system.

The basic software approval is carried out in the following phases:

- Examination of the documents as required in Sec 1, [2.3.2],
- Verification that all the development work has been carried out according to the quality procedure. The complementary documents required in Tab 2 prove the quality of the development work.

Note 1: Particular attention will be given to the test results collected on unit testing file, integration test file and validation test file

- Repetition of tests of the essential function of the software. Comparison with documentation containing the test results of previous tests is to be carried out.

2.3.4 The application software is to be approved on a case by case basis, according to [3.3.2].

2.4 Loading instruments

2.4.1

Loading instrument approval consists of:

- approval of hardware according to [2.2], unless two computers are available on board for loading calculations only
- for programmable loading instruments, approval of basic software according to [2.3]
- approval of application software, consisting in data verification which results in the Endorsed Test Condition according to Part B
- installation testing according to [4].

Table 2 : Basic software development documents

No.	I/A **(2)**	DOCUMENT
1	I	Follow-up of developed software: identification, safeguard, storage
2	I	Document showing the capability and training of the development team
3	I	Production of a specification file
4	I	Production of a preliminary design file
5	I	Production of a detailed design file
6	I	Production of a coding file
7	I	Production of a unit testing file **(1)**
8	I	Production of an integration test file **(1)**
9	I	Production of a validation test file **(1)**
10	I	Production of a maintenance facility file
11	I	Production of a quality plan
12	I	Follow-up of the quality plan: checks, audits, inspections, reviews

(1) Complementary test carried out, at random, at the request of the Surveyor
(2) A : to be submitted for approval;
I : to be submitted for information.

3 Acceptance testing

3.1 Hardware testing

3.1.1 Hardware acceptance tests include, where applicable:

- visual inspection
- operational tests and, in particular:
    - tests of all alarm and safety functions

  - verification of the required performance (range, calibration, repeatability, etc.) for analogue sensors
  - verification of the required performance (range, set points, etc.) for on/off sensors
  - verification of the required performance (range, response time, etc.) for actuators
  - verification of the required performance (full scale, etc.) for indicating instruments
- high voltage test
- hydrostatic tests.

Additional tests may be required by the Society.

3.1.2 Final acceptance will be granted subject to:
- the results of the tests listed in [3.2.1]
- the type test report or type approval certificate.

3.2 Software testing

3.2.1 Software acceptance tests of programmable electronic systems are to be carried out to verify their adaptation to their use on board, and concern mainly the application software.

3.2.2 The software modules of the application software are to be tested individually and subsequently subjected to an integration test. The test results are to be documented and to be part of the final file. It is to be checked that:
- the development work has been carried out in accordance with the plan
- the documentation includes the proposed tests, the acceptance criteria and the result.

Repetition tests may be required to verify the consistency of test results.

3.2.3 Software acceptance will be granted subject to:
- examination of the available documentation
- a functional test of the whole system.

The Society may ask for additional tests of systems which are part of safety systems or which integrate several functions.

4 Commissioning

4.1 General

4.1.1 Commissioning tests are to be carried out on automation systems associated with essential services to verify their compliance with the Rules, by means of visual inspection and the performance and functionality according to Tab 3.

When completed, automation systems are to be such that a single failure, for example loss of power supply, is not to result in a major degradation of the propulsion or steering of the yacht. In addition, a blackout test is to be carried out to show that automation systems are continuously supplied.

Upon completion of commissioning tests, test reports are to be made available to the Surveyor.

Table 3 : Commissioning tests

Equipment	Nature of tests
Electronic equipment	Main hardware functionality
Analogue sensors	Signal calibration, trip set point adjustment
On/off sensors	Simulation of parameter to verify and record the set points
Actuators	Checking of operation in whole range and performance (response time, pumping)
Reading instruments	Checking of calibration, full scale and standard reference value

APPENDIX 1 ALTERNATIVES, RELAXATIONS AND ADDITIONAL CONSIDERATIONS FOR YACHTS OF LESS THAN 500GT

1 General Requirement (Section 1)

1.1 General

1.1.1 With reference to Pt. C Ch.3 Section 1, when allowed in pt A Ch.2 App.3, par. [1.4.1] is not mandatory.

1.1.2 With reference to Pt. C Ch.3 Section 1, [2], following drawings listed in Table 1 need not to be sent: Instruction manuals and Diagram of the engineers' alarm system.

1.1.3 With reference to Pt. C Ch.3 Section 1, par. [2.3.1] to [2.4] and Table 2, when allowed in pt A Ch.2 App.3, as an alternative what at [1.1.4] may be applied.

1.1.4 ISO 9001 or ISO 90003 certification, or equivalent, stating that the system integrator and the software developer quality software development is in compliance with an international or national standard. If the above certification is not available, then the following documentation is to be sent:

- procedures regarding responsibilities, system documentation, configuration management and staff competency;
- procedures regarding software and associated hardware lifecycle:
  - organization set in place for acquisition of related hardware and software from suppliers (if mandatory);
  - organization set in place for software code writing and verification
  - organization set in place for system validation before integration in the vessel

In addition, the following documentation is to be submitted:

- General functional description of software and associated hardware;
- System block diagram, showing the arrangement of individual parts, input and output devices and interconnections.
- Test programs and procedures for functional on board test,
- List and versions of software(s) installed in system,
- User manual including instructions during software maintenance.

1.1.5 With reference to Pt C, Ch 3, Sec 1, when allowed in Pt A, Ch 2, App 3, [4.2] is not mandatory.

2 Design Requirement (Section 2)

2.1 General

2.1.1 With reference to Pt C, Ch 3, Sec 2, when allowed in Pt A, Ch 2, App 3, [2], as an alternative what at [2.1.2] may be applied.

2.1.2 The automation system is to be continuously powered. Failure of the power supply is to generate an alarm. Each automation system is to have separate power supplies with short circuit and overload protection. Safety systems are to have power supplies as far as possible separate from control and alarm system, or an equivalent safety level is to be ensured.

2.2 Control of propulsion machinery

2.2.1 With reference to Pt C, Ch 3, Sec 2, when allowed in Pt A, Ch 2, App 3, [4.1.4], is not mandatory.

3 Computer Based Systems (Section 3)

3.1 General

3.1.1 *(1/1/2025)*
With reference to Pt C, Ch 3, App 3 "Guidance for the application of Section 3 on Computer Based Systems", as an alternative to [2.1.1 a)] for category II and III services only, the software version (or release) is to be communicated**.**

4 Constructional Requirements (Section 4)

4.1 General

4.1.1 With reference to Pt C, Ch 3, Sec 4, when allowed in Pt A, Ch 2, App 3, [2.2.6] is not mandatory.

5 Testing (Section 6)

5.1 General

5.1.1 With reference to Pt C, Ch 3, Sec 6, [1.1], when allowed in Pt A, Ch 2, App 3, as an alternative what at [5.1.2] maybe applied

5.1.2 Automation systems are to be commissioned when installed on board and prior to sea trials, to verify their performance and adaptation on site. Commissioning tests are to be carried out on automation systems associated with essential services to verify their compliance with the Rules, by means of visual inspection, functional tests according to Sec.6 Tab 3 2Commisioning Tests”. When completed, automation systems are to be such that a single failure, for example loss of power supply, will not result in a major degradation of the propulsion or steering of the craft. Adequate spare parts are to be provided. A blackout test is to be carried out to show that automation systems are continuously supplied. Upon completion of the commissioning tests, test re-ports are to be made available to the Surveyor.

5.1.3 With reference to Pt C, Ch 3, Sec 6, when allowed in Pt A, Ch 2, App 3, [2] is not mandatory.

5.1.4 With reference to Pt C, Ch 3, Sec 6, when allowed in Pt A, Ch 2, App 3, [3] is not mandatory.

APPENDIX 2 ALTERNATIVES, RELAXATIONS AND ADDITIONAL CONSIDERATIONS FOR YACHTS OF LESS THAN 24M LLL

1 Application

1.1 General

1.1.1 For Yachts with length LLL not exceeding 24 m in length, Part C, Chapter 3 is not applicable.

1.1.2 Automation systems are to be commissioned when installed on board, to verify their correct installation, performance and adaptation on site. Commissioning tests are to be carried out on automation systems associated with essential services to verify their proper installation, performance and functionality.

APPENDIX 3 GUIDANCE FOR THE APPLICATION OF SECTION 3 ON COMPUTER BASED SYSTEMS

1 Application

1.1 Introduction

1.1.1 Since the categorization of a system is strictly function of the design of the yacht and software applications can be originated from a wide range of solutions, the correct and final approval path for a computer-based system software is to be defined in the first stages of the yacht design.

1.1.2 It is to be noted that the main aim of Section 3 is to give the detailed description of a complete software approval process which it is to be applied only to some computer-based systems installed on board of a yacht defined at the beginning of the project. For other Computer based system a case-by-case procedure may be applied.

1.1.3 The standard minimum information or documents that are to be anyway sent to the Society concerning computer-based systems are reported in [2].

2 Design Requirements

2.1 Software version (or release)

2.1.1 Software version (or release) of each programmable device (computer) which manages the following services or systems is to be communicated after onboard functioning tests performed with surveyor attendance, but before the date of the yacht Certificate of Classification issue:

a) Single essential or safety service (e.g. steering automation system, main propulsion engine control system, navigation lights automation system, bilges alarms system)

b) Vessel automation/monitoring system (even if its correct functioning is not necessary for the vessel proper operation and safety)

c) Integrated automation system which correct functioning is necessary for the vessel proper operation and safety (e.g. power management system, energy management system, AUT-UMS system)

2.2 Integrated Automation System

2.2.1 With reference to those systems as described at [2.1.1] point c), the following documents are to be submitted:

a) Hardware FMEA and Risk Assessment,

b) Software FMEA or internal software tests report,

c) System acceptance test (SAT) to be performed on board,

d) Software change management and backup restoring procedures,

e) Software supplier quality plan, choosing one of the following:

- ISO (or other national or international recognized standard) certificate(s) concerning quality software development;
- Set of documents which describes supplier organization, roles, internal checks set in place for software development and commissioning (see Appendix 1, [1.1.4]).

Chapter 4

FIRE PROTECTION, DETECTION AND EXTINCTION

SECTION 1 GENERAL REQUIREMENTS

1 Definitions

1.1 Application

1.1.1 This Chapter is applicable, in general, in case the Society does not carry out the compliance activity to an Administration Safety Code deemed considered as an equivalent standard.

1.1.2 In case of matters not delegated to class by the Administration (i.e. means of escape) the approval of the Flag Administration may be accepted on a case by case base.

1.1.3 The Rules of an Administration recognized acceptable by Tasneef may be considered alternative to this chapter with the exception of the following paragraph that have to applied in any case:

- Pt C, Ch 4, Sec 6, [2.1.1] for newbuilding yachts

1.2 Definitions

1.2.1 The definition used in this chapter are those contained in SOLAS and other IMO publications. In addition some other definitions are reported here below.

1.2.2 Not readily ignitable
When the surface thus described will not continue to burn for more than 20 seconds after removal of a suitable impinging test flame.

1.2.3 Standard fire test
A test in which the representative specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding to the standard time-temperature curve in accordance with the Fire Test Procedures Code. The dimensions of the specimens may be agreed with Tasneef.

For composite structures, considering that:

a) the absolute temperature is not to reach the Heat Deflection Temperature during the fire test;

b) the increase of temperature above the ambient temperature is to measured according to the IMO FTP Code; and

c) the ambient temperature may influence the test results since the increase of the sample temperature during a fire resistance test is normally independent from the ambient temperature

the fire resistance tests to evaluate the acceptance of the proposed insulation are to be carried out measuring the temperature increase above a standard ambient temperature normally set at 30°C.

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

1.2.5 Battery charging station
A permanently (fixed) integrated element of the vessel electrical plant for the recharging of plug-in equipment. A fixed charging station provides electrical conversion, monitoring, or safety functionality. Standard electrical sockets or outlets are not to be considered fixed charging stations.

2 Documentation to be submitted

2.1

2.1.1 The Interested Party is to submit to Tasneef the documents listed in Tab 1.

Table 1 : Documentation to be submitted

No	I/A **(1)**	Document **(2)**
1	A	Structural fire protection, showing the method of construction and the purpose of the various spaces of the yacht
2	A	Natural and mechanical ventilation systems showing the penetrations of class divisions, location of dampers, means of closing, arrangements of air conditioning rooms
3	A	Means of escape
4	A	Automatic fire detection systems and manually operated call points
5	A	Location of fire pumps and fire mains (with indication of pump head and capacity), hydrants and fire hoses
6	A	Arrangement of fixed fire-extinguishing systems **(2)**
7	A	Fire-fighting mobile equipment and firemen's outfits
8	A	Electrical diagram of fixed fire-extinguishing systems and fire pumps
9	A	Electrical diagram of power control and position indication circuits for fire doors
10	I	General arrangement plan
11	A	Sprinkler systems or equivalent systems, if any **(2)**
12	A	Electrical diagram of the sprinkler systems, if any
13	A	General arrangement plan relevant to the vehicle spaces showing the fire systems, ventilation systems and other safety systems adopted for such spaces

(1) A: to be submitted for approval in four copies
I : to be submitted for information in duplicate

(2) Plans are to be schematic and functional and to contain all information necessary for their correct interpretation and verification such as:
- service pressures
- capacity and head of pumps and compressors, if any
- materials and dimensions of piping and associated fittings
- volumes of protected spaces, for gas and foam fire-extinguishing systems
- surface areas of protected zones for automatic sprinkler and pressure water-spraying, low expansion foam and powder fire-extinguishing systems
- capacity, in volume and/or in mass, of vessels or bottles containing the extinguishing media or propelling gases, for gas, automatic sprinkler, foam and powder fire-extinguishing systems
- type, number and location of nozzles of extinguishing media for gas, automatic sprinkler, pressure water-spraying, foam and powder fire-extinguishing systems.

All or part of the information may be provided, instead of on the above plans, in suitable operation manuals or in specifications of the systems.

3 Type Approved Products

3.1

3.1.1 In general the following materials, equipment or products to be used for fire protection are to be type approved by Tasneef. In special cases Tasneef may accept a Type Approval Certificate issued by another recognised organisation, or, for individual yachts, Tasneef may consider acceptance on the basis of ad hoc tests.

a) Fire-resisting and fire-retarding divisions (bulkheads or decks) and associated doors

b) Materials with low flame spread characteristic when they are required to have such characteristic

c) Fixed foam fire-extinguishing systems and associated foam-forming liquids

d) Fixed powder fire-extinguishing systems, including the powder

e) Non-combustible materials

f) Sprinkler heads for automatic sprinkler systems

g) Nozzles for fixed pressure water-spraying fire-extinguishing systems for machinery spaces and vehicle spaces

h) Sensing heads for automatic fire alarm and fire detection systems

i) Fixed fire detection and fire alarm systems

j) Fire dampers

k) Equivalent water-based fire-extinguishing systems for machinery spaces of category A

l) Equivalent fixed gas fire-extinguishing system components for machinery spaces of category A

m) Other fixed fire-extinguishing systems different from those listed above

n) portable fire extinguishers.

Tasneef may request type approval for other materials, equipment, systems or products for installations of special types.

4 Fire control plan

4.1 General

4.1.1 The fire control plan is to be provided and displayed on board, show and describe the principal fire prevention and protection equipment and material.

On this basis such plans are to be developed as general arrangement plans containing the following details:

- class divisions relevant to the bulkhead and decks of the various spaces. Such spaces are to be identified with the same numeration as defined in Sec 3
- control stations
- schematic scheme showing the fire detection and fire alarm systems
- schematic scheme showing the installed fire-fighting systems
- means of escape from the various compartments
- ventilating system
- location and means of control of systems and openings which are to be closed in the case of a fire event
- location and characteristics of the fire appliances.

The above plans are to be exhibited in a dedicated position on the yacht for guidance of the personnel on board.

Plans are to be kept up to date.

SECTION 2 FIRE PREVENTION

1 Engine space arrangement

1.1

1.1.1 The boundary of the engine space is to be arranged in order to contain the fire-extinguishing medium so that it cannot escape.

1.1.2 Combustible materials and flammable liquid excluding fuel oil necessary for the propulsion engines are not to be stowed in the engine space.

1.1.3 Machinery spaces of category A and engine spaces are to be ventilated to prevent the build-up of explosive gases.

1.1.4 For yachts with wooden hulls, particular attention is to be paid in order to adopt adequate means to avoid oil absorption into the structures.

1.1.5 In order to contain the oil, it may be acceptable to fit a drip tray in way of the engine. The use of the engine bearers as a means of containment of the oil may be accepted provided that they are of sufficient height and have no limber holes.

Efficient means are to be provided to ensure that all residues of persistent oils are collected and retained on board for discharge to collection facilities ashore.

1.1.6 Means are to be adopted for the storage, distribution and utilisation of fuel oil in order to minimise the risk of fire.

1.1.7 Fuel oil, lubricating oil and other flammable liquids are not to be stored in fore peak tanks.

1.1.8 Fuel oil tanks situated within, or adjacent to, the boundaries of category A machinery spaces are not to contain fuel oil having a flashpoint of less than 60ºC.

1.1.9 Every fuel oil pipe which, if damaged, would allow oil to escape from a storage, settling or daily service tank situated above the double bottom is to be fitted with a cock or valve directly on the tank. Such cock or valve is to be capable of being closed locally and from a safe position outside the space in which such tanks are fitted in the event of fire occurring in the space (see also Ch 1, Sec 9, [9.6.3]).

1.1.10 Means are to be provided to stop fuel transfer pumps, fans and separators from outside the machinery space.

2 Liquid petroleum gas for domestic purposes

2.1

2.1.1 Where gaseous fuel is used for domestic purposes, the arrangements for the storage, distribution and utilisation of the fuel is to be such that, having regard to the hazards of fire and explosion which the use of such fuel may entail, the safety of the yacht and the persons on board is preserved. The installation is to be in accordance with App 1 or other recognised national or international standards.

Hydrocarbon gas detectors and carbon monoxide detectors are to be provided.

2.1.2 Open flame gas appliances fitted on board for cooking, heating or any other purpose are to be in compliance with recognised international standards.

2.1.3 Materials which are fitted close to open flame cooking and heating appliances are to be non-combustible, except that the exposed surfaces of these materials are to be protected with a finish having a class 1 surface spread of flame rating when tested in accordance with ASTM D 635.

Where combustible materials or other materials which do not have a class 1 surface spread of flame rating are fitted, they are not to be placed unprotected within the following distances of a standard cooker:

a) 400 mm vertically above the cooker, for horizontal surfaces, when the vessel is upright;

b) 125 mm horizontally from the cooker, for vertical surfaces.

2.1.4 Curtains or any other suspended textile materials are not to be fitted within 600 mm of any open flame cooking, heating or other appliance.

2.1.5 After the completion of the installation on board, the system is to be checked at operating pressure by means of a pneumatic test.

When all leakage has been repaired, all appliance valves are to be closed and the cylinder shut-off valve opened.

When the gauge registers that the system is pressurised, the cylinder valve is to be closed.

It is to be verified that the pressure reading value remains constant for at least 15 minutes.

2.1.6 An open flame gas appliance provided for cooking, heating or any other purpose is to comply with the requirements of EC Directive 90/396/EEC or equivalent.

2.1.7 Compartments for gas cylinders are to be fitted with:

- effective natural ventilation, and
- doors that open outwards and are directly accessible from the open deck, and
- bulkhead doors and other means of closing any openings gas-tight to the vessel's interior, separating such compartments from adjoining spaces.

3 Deep fat frying equipment

3.1 General

3.1.1 Attention is drawn to the requirements of SOLAS II-2/10.6.4 for fire-extinguishing systems for deep fat cooking equipment.

For fryers of up to 15 litres cooking oil capacity, the provision of a suitably sized class F extinguisher (BS7937:2000) together with manual isolation of the electrical power supply is acceptable.

4 Space heaters

4.1 General requirements

4.1.1 Space heaters, if used, are to be fixed in position and so constructed as to reduce fire risks to a minimum. The design and location of these units is to be such that clothing, curtains or other similar materials cannot be scorched or set on fire by heat from the unit.

5 Materials

5.1

5.1.1 Except in refrigerated compartments of service spaces, all insulation (e.g. fire and comfort) is to be of non-combustible.

5.1.2 In spaces where penetration of oil products is possible, the surface of insulation is to be impervious to oil or oil vapours. Insulation boundaries are to be arranged to avoid immersion in oil spillages.

5.1.3 Vapour barriers and adhesives used in conjunction with insulation, as well as insulation of pipe fittings for the cold service system, need not be non-combustible, but they are to be kept to the minimum quantity practicable and their exposed surfaces are to have low flame spread characteristics.

5.1.4 Paints, varnishes and other surface finishes to be used in machinery spaces, galleys and spaces with fire risk are not to be capable of producing excessive quantities of smoke or toxic products when they burn, this being determined in accordance with the Fire Test Procedures Code.

6 Batteries charging station

6.1

6.1.1 Batteries charging: movable/Portable batteries, of a type other than Lead and Nickel-Cadmium batteries (including batteries fitted on onboard equipment, toys, appliances etc.), during the charging process shall be placed in a well ventilated area onboard which is either an open deck, or in a continuously manned area or an area which is covered by a gas, smoke and heat detection system and an automatic fixed fire extinguishing system.

In all other cases the relevant requirements of Pt C, Ch 2, App 4 will be applied on a risk assessment base.

SECTION 3 FIRE CONTAINMENT

1 Structure

1.1 General

1.1.1 The purpose of these provisions is to contain a fire in the space of origin.

For this purpose, the following functional requirements are to be met:

- the yacht is to be subdivided by thermal and structural boundaries as required by these Rules
- thermal insulation of boundaries is to have due regard to the fire risk of the space and adjacent spaces
- the fire integrity of the division is to be maintained at openings and penetrations.

2 Forms of construction - fire divisions

2.1

2.1.1 When fire divisions are required in compliance with these Rules, they are to be constructed in accordance with the following requirements.

2.1.2 Fire divisions using steel equivalent, or alternative forms of construction, may be accepted if it can be demonstrated that the material by itself, or due to non-combustible insulation provided, has fire resistance properties equivalent to those divisions required by these Rules.

2.1.3 Insulation is to be such that the temperature of the structural core does not rise above the point at which the structure would begin to lose its strength at any time during the applicable exposure to the standard fire test. For A class divisions, the applicable exposure is 60 minutes, and for B class divisions, the applicable exposure is 30 minutes.

2.1.4 For aluminium alloy structures, the insulation is to be such that the temperature of the structural core does not rise more than 200ºC above the ambient temperature at any time during the applicable fire exposure.

2.1.5 For composite structures, the insulation is to be such that the temperature of the laminate does not rise more than the minimum temperature of deflection under load of the resin at any time during the applicable fire exposure. The temperature of deflection under load is to be determined in accordance with a recognised international standard.

2.1.6 Insulation need only be applied on the side that is exposed to the greater fire risk; inside the engine room, a division between two such spaces is, however, to be insulated on both sides unless it is a steel division.

2.1.7 Special attention is to be given to the fixing of fire door frames in bulkheads constructed of materials other than steel. Measures are to be taken to ensure that the temperature of the fixings when exposed to fire does not exceed the temperature at which the bulkhead itself loses strength.

2.2 Equivalent fire division accepted without the exposure to the standard fire test

2.2.1 When fire divisions are required according to these Rules, the following may be accepted without the fire test.

Table 1

Type of material	B15 Class Division	A-30 Class Division
Composite material	• two 25 mm layers of non-combustible high density mineral wool suitably alternated. The mineral wool is to have a minimum volumetric mass of 100 kg/m3. The outer surface of the mineral wool is to be suitably protected against any splashing from fuel oil or other flammable liquid, or • reinforced plastic of thickness not less than 13 mm with a final layer of self-extinguishing laminates (for a thickness not less than 1,5 mm)	• two 30 mm layers of non-combustible high density mineral wool suitably alternated. The mineral wool is to have a minimum volumetric mass of 130 kg/m^3. The outer surface of the mineral wool is to be suitably protected against any splashing from fuel oil or other flammable liquid.
Aluminium alloy plate		5,5 mm aluminium alloy plate thickness insulated with 80 mm of non-combustible high density mineral wool. The mineral wool is to have a minimum volumetric mass of 100 kg/m3. The outer surface of the mineral wool is to be suitably protected against any splashing from fuel oil or other flammable liquid.
Steel plate		4,0 mm steel plate thickness insulated with 50 mm of non-combustible high density mineral wool. The mineral wool is to have a minimum volumetric mass of 100 kg/m^3. The outer surface of the mineral wool is to be suitably protected against any splashing from fuel oil or other flammable liquid.

3 Class divisions

3.1 Class divisions

3.1.1 With reference to the classification of the various spaces referred to here, the following definitions are to be considered:

a) Control stations
- Spaces containing emergency sources of power and lighting
- Wheelhouse and chartroom
- Spaces containing the vessel's radio equipment
- Fire-extinguishing rooms
- Fire control rooms and fire-recording stations
- Control room for propulsion machinery when located outside the machinery space
- Spaces containing centralised fire alarm equipment

b) Corridors and lobbies
- Guest and crew corridors and lobbies

c) Accommodation spaces
- Cabins, dining rooms, lounges, offices, pantries containing no cooking appliances (other than equipment such as microwave cookers and toasters), and similar spaces

d) Stairways

- Interior stairways, lifts and escalators (other than those wholly contained within the machinery space(s)) and enclosures thereto.
- In this connection, a stairway which is enclosed only at one level is to be regarded as part of the space from which it is not separated by a fire door.

e) Service spaces (low risk)

- Lockers and storerooms not having provision for the storage of flammable liquids and having areas less than 4m2, and drying rooms and laundries

f) Machinery spaces of category A

- Spaces so defined.

g) Other machinery spaces

- Spaces so defined, excluding machinery spaces of category A
- Sprinkler, drencher or fire pump spaces

h) Service spaces (high risk)

- Galleys, pantries containing cooking appliances, paint and lamp rooms, lockers and storerooms having areas of 4 m2 or more, spaces for the storage of flammable liquids, workshops other than those forming part of the machinery spaces, and spaces containing vehicles or craft with fuel in their tanks, or lockers storing such fuels and storage lockers for gaseous fuels for domestic purposes

i) Open decks

- Open deck spaces and enclosed promenades having no fire risk. Air spaces (the space outside superstructures and deckhouses).

3.1.2 Category A machinery spaces are to be separated from accommodation spaces, service spaces, control stations, stairways and corridors by A-60 class divisions.

3.1.3 Corridors are to be separated from accommodation spaces, stairways and service spaces with low risk by B-0 class divisions.

3.1.4 Corridors are to be separated from control stations, other machinery spaces and service spaces with high risk by A-0 class divisions.

3.1.5 All bulkheads required to be B class divisions are to be extended from deck to deck unless a continuous ceiling in B class divisions is fitted.

3.1.6 For structures in contact with sea water, the required insulation is to extend to at least 300 mm below the lightest waterline.

3.1.7 Except in spaces protected by an automatic sprinkler system and fully addressable fire detection system, all linings, flooring and ceilings are to be of noncombustible materials.

3.1.8 Openings in A and B class divisions are to be provided with permanently attached means of closing that are to be at least as effective for resisting fires as the divisions in which they are fitted. Generally, windows are not to be fitted in machinery space boundaries.

3.1.9 Where A or B class divisions are penetrated for the passage of electrical cables, pipes, trunks, ducts, etc, or for girders, beams or other structural members, arrangements are to be made to ensure that the fire resistance is not impaired.

3.1.10 Where the structure or A class divisions are required to be insulated, it is to be ensured that the heat from a fire is not transmitted through the intersections and terminal points of the divisions or penetrations to uninsulated boundaries. Where the insulation installed does not achieve this, arrangements are to be made to prevent this heat transmission by insulating the horizontal and vertical boundaries or penetrations for a distance of 450 mm (this may be reduced to 380 mm on steel divisions only).

3.1.11 Shaft seals and other parts of shaft line arrangement that if damaged by a fire would cause the ingress of water into the hull, have to be made of metallic material, only small parts can be non metallic, provided that they are protected from the effect of a fire or be reasonably fire resistant.

3.2 Protection of stairways, dumb waiters and lifts in accommodation and service spaces

3.2.1 Stairways are to be separated from other spaces by enclosures having class divisions at least A0. Stairways are to be of steel construction. Tasneef may consider different materials provided that equivalent fire resistance as for steel is ensured.

3.2.2 A stairway is to be provided with positive means of closure at all openings, except that:

a) an isolated stairway which penetrates a single deck only may be protected at one level only by at least B class divisions and self-closing door(s); and

b) stairways may be fitted in the open in a public space, provided they lie wholly within such public space.

In so far as is practical, stairway enclosures are not to give direct access to galleys, machinery spaces, service lockers (high fire risk category 8) or other enclosed spaces containing combustibles in which a fire is likely to originate.

A lift trunk is to be so fitted as to prevent the passage of flame from one 'tweendeck to another and is to be provided with means of closing to permit the control of draught and smoke.

3.2.3 *(1/1/2025)*

Dumb waiters are to be enclosed (trunk and door) at least in class A0 (B-15 for short range yachts).

3.3 Construction and arrangement of saunas

3.3.1 The perimeter of the sauna is to be of A class boundaries and may include changing rooms, showers and toilets. The sauna is to be insulated to A- 60 against other spaces except those inside of the perimeter. For infrared sauna the above mentioned fire divisions are not mandatory if less than 2kW and 150°C otherwise may be reduced to A0.

3.3.2 Bathrooms with direct access to saunas may be considered as part of them. In such cases, the door between the sauna and the bathroom need not comply with fire safety requirements.

3.3.3 Wooden linings on bulkheads and ceilings are permitted.

The ceiling above the oven is to be lined with a non- combustible plate with an air gap of at least 30 mm. The distance from the hot surfaces to combustible materials is to be at least 500 mm or the combustible materials are to be protected (e.g. non-combustible plate with an air gap of at least 30 mm).

Wooden benches are permitted.

The sauna door is to open outwards by pushing.

Electrically heated ovens are to be provided with a timer.

All spaces within the perimeter of the sauna shall be protected by a fire detection and alarm system and an automatic sprinkler system.

3.4 Construction and arrangement of Thermal Suite (e.g. Steam Room)

3.4.1 The perimeter of the thermal suite may include changing rooms, showers and toilets.

3.4.2 Bathrooms with direct access to the suite may be considered as part of it. In such cases, the door between the suite and the bathroom need not comply with fire safety requirements.

3.4.3 *(1/1/2025)*

If the steam generator of more than 5 kW is contained within the perimeter, the suite boundary is to be constructed to an A-0 standard . If the steam generator of more than 5 kW is not contained within the perimeter, the steam generator is to be protected by A-0 standard divisions and pipes leading to the discharge nozzles should be lagged.

3.4.4 If a suite arrangement contains a sauna then the requirements contained in [3.1] are applicable, regardless of the steam generator location.

3.4.5 All spaces within the perimeter are to be protected by a fire detection and alarm system.

3.5 Openings in A class divisions

3.5.1 The construction of all doors and door frames in A class divisions, with the means of securing them when closed, is to provide resistance to fire as well as the passage of smoke and flame, as far as practical, equivalent to that of the bulkheads in which the doors are situated. Such doors and door frames are to be constructed of steel or other equivalent material. Steel watertight doors need not be insulated.

3.5.2 Fire doors in galley boundaries and stairway enclosures, other than power-operated watertight doors and those which are normally locked, are to satisfy the following requirements:

a) the doors are to be self-closing and be capable of closing with an angle of inclination of up to 3,5Âº opposing closure;

b) the approximate time of closure for hinged fire doors is to be no more than 40 seconds and no less than 10 seconds from the beginning of their movement with the yacht in the upright position. The approximate uniform rate of closure for sliding doors is to be no more than 0,2 m/s and no less than 0,1 m/s with the yacht in the upright position;

c) the doors, except those for emergency escape trunks, are to be capable of remote release from the continuously manned central control station, either simultaneously or in groups and are also to be capable of release, individually, from a position at the door. Release switches are to have an on-off function to prevent automatic resetting of the system;

d) hold-back hooks not subject to central control station release are prohibited;

e) a door closed remotely from the central control station is to be capable of being reopened from both sides of the door by local control. After such local opening, the door is to automatically close again;

f) indication is to be provided at the fire door indicator panel in the continuously manned central control station whether each door is closed;

g) the release mechanism is to be so designed that the door will automatically close in the event of disruption of the control system or central power supply;

h) local power accumulators for power-operated doors are to be provided in the immediate vicinity of the doors to enable the doors to be operated after disruption of the control system or central power supply at least ten times (fully opened and closed) using the local controls;

i) disruption of the control system or central power supply at one door is not to impair the safe functioning of the other doors

j) remote-released sliding or power-operated doors are to be equipped with an alarm that sounds at least 5s but no more than 10s after the door being released from the central control station and before the door begins to move and continues sounding until the door is completely closed;

k) a door designed to reopen upon contacting an object in its path is to reopen not more than 1m from the point of contact;

l) double-leaf doors equipped with a latch necessary for their fire integrity are to have a latch that is automatically activated by the operation of the doors when released by the system;

m) the components of the local control system are to be accessible for maintenance and adjusting;

n) power-operated doors are to be provided with a control system of an approved type which is to be able to operate in case of fire and is to be in accordance with the Fire Test Procedures Code. This system is to satisfy the following requirements:

This system is to satisfy the following requirements:

- the control system is to be able to operate the door at a temperature of at least 200ºC for at least 60min, served by the power supply;
- the power supply for all other doors not subjected to fire is not to be impaired; and
- at temperatures exceeding 200ºC the control system is to be automatically isolated from the power supply and is to be capable of keeping the door closed up to at least 945ºC.

3.6 Openings in B class divisions

3.6.1 Doors and door frames in B class divisions and means of securing them are to provide a method of closure which has resistance to fire as far as practical equivalent to that of the divisions, except that a ventilation opening may be permitted in the lower portion of such doors.

When such an opening is in or under a door, the total net area of the opening(s) is not to exceed 0,05m2. When such an opening is cut in a door it is to be fitted with a grill made of non-combustible material. Doors are to be noncombustible or of substantial construction.

3.6.2 Where B class divisions are penetrated for the passage of electrical cables, pipes, trunks, ducts, etc, or for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements are to be made to ensure that the fire resistance is not impaired.

3.7 Windows and portlights

3.7.1 All windows and portlights in bulkheads within accommodation spaces, service spaces and control stations are to be so constructed as to preserve the integrity requirements of the type of bulkheads in which they are fitted.

3.8 Details of construction

3.8.1 Where the structure or A class divisions are required to be insulated, it is to be ensured that the heat from a fire is not transmitted through the intersections and terminal points of the divisions or penetrations to uninsulated boundaries.

Where the insulation installed does not achieve this, arrangements are to be made to prevent this heat transmission by insulating the horizontal and vertical boundaries or penetrations for a distance of 450 mm.

3.8.2 Without impairing the efficiency of the fire protection, the construction of ceilings and bulkheads is to allow a fire patrol to detect any smoke originating in concealed and inaccessible places, except where there is no risk of fire originating in such places.

3.8.3 When gaseous fuel is used for domestic purposes, the arrangements for the storage, distribution and utilisation of the fuel are to be such that, having regard to the hazards of fire and explosion which the use of such fuel may entail, the safety of the vessel and the persons on board are preserved.

In particular, open flame gas appliances provided for cooking, heating or any other purposes are to comply with the requirements of EC directive 90/396/EEC or equivalent and the installation of open flame gas appliances is to comply with the appropriate provisions of Section 2, [2.1].

4 Ventilating systems

4.1 General

4.1.1 Ventilation fans for machinery spaces and enclosed galleys are to be capable of being stopped and main inlets and outlets of the ventilation system closed from outside the spaces being served. This position is not to be readily cut off in the event of a fire in the spaces served.

4.1.2 Ventilation ducts serving category A machinery spaces, galleys, spaces containing vehicles or craft with fuel in their tanks, or lockers containing fuel tanks are not to cross accommodation spaces, service spaces or control stations unless the trunking is constructed of steel (minimum thickness 4mm). The ducting within the accommodation is to be fitted with fire insulation to A-60 to a point at least 5m from the machinery space or galley.

4.1.3 Where the trunking passes from the machinery space or galley into the accommodation, automatic fire dampers are to be provided in the deck or bulkhead within the accommodation. The automatic fire dampers are also to be manually operable from outside the machinery space or galley.

4.1.4 The requirements in [4.1.2] and [4.1.3] also apply to ventilation ducts for accommodation spaces passing within category A machinery spaces.

4.1.5 Storerooms containing highly flammable products are to be provided with ventilation arrangements that are separate from other ventilation systems. Ventilation is to be arranged to prevent the build-up of flammable vapours at high and low levels. The inlets and outlets of ventilators are to be positioned so that they do not draw from or vent into an area which would cause undue hazard, and are to be fitted with spark arresters.

4.1.6 Enclosed spaces in which generating sets and freestanding fuel tanks are installed are to be ventilated independently of systems serving other spaces, in order to avoid the accumulation of vapours, to allow discharge into the open air and to supply the air necessary for the service of the installed engine according to the Manufacturer's specifications. The inlet and outlets of ventilators are to be positioned so that they do not draw from or vent into an area which would cause undue hazard, and are to be fitted with spark arresters.

4.1.7 Ventilation systems serving category A machinery spaces are to be independent of systems serving other spaces.

4.1.8 Adequate means of ventilation are to be provided to prevent the accumulation of dangerous concentrations of flammable gas which may be emitted from batteries.

4.1.9 All inlet and outlet ducts are to be provided with adequate weathertight means of closure operable from a readily accessible position.

SECTION 4 FIRE DETECTION

1 General

1.1

1.1.1 The purpose of this Section is to detect a fire in the space of origin and to provide for an alarm for safe escape and fire-fighting activity.

2 Fixed fire detection and fire alarm systems

2.1 General

2.1.1 A fixed fire detection and fire alarm system is to be fitted in all enclosed spaces except those containing no significant fire risk (toilets, bathrooms, void spaces, etc).

The system is to meet the following functional requirements:

- fixed fire detection and fire alarm system installations are to be suitable for the nature of the space, fire growth potential and potential generation of smoke and gases; and
- manually operated call points are to be placed effectively to ensure a readily accessible means of notification.

The fixed fire detection and fire alarm system is to be installed in accordance with the requirements of SOLAS II- 2/7 and the IMO Fire Safety Systems Code, Chapter 9.

2.1.2 Manually operated call points complying with the requirements of SOLAS II-2/7 and the IMO FSS Code, Chapter 9 are to be installed. Manually operated call points shall be placed to ensure a readily accessible means of notification.

2.1.3 In addition to the requirements mentioned in SOLAS regulation II-2/7 and Chapter 9 of the IMO Fire Safety Systems Code, the main (respective emergency) feeder of the fire detector and alarm system is to run from the main (respective emergency) switchboard to the change-over switch without passing through any other distributing switchboard.

SECTION 5 MEANS OF ESCAPE

1 General

1.1

1.1.1 The purpose of this Section is to provide means of escape so that persons on board can safely and swiftly escape to the liferaft embarkation deck. For this purpose, the following functional requirements are to be met:

- safe escape routes are to be provided
- escape routes are to be maintained in a safe condition, clear of obstacles; and
- additional aids for escape are to be provided as necessary to ensure accessibility, clear marking and adequate design for emergency situations.

1.1.2 Control stations are to be arranged for the convenience of the operator.

1.1.3 Automation components are to be properly fitted. Screws and nuts are to be locked, where necessary.

1.2 General requirements

1.2.1 Stairways, ladders and corridors serving all spaces normally accessible are to be arranged so as to provide ready means of escape to a deck from which embarkation into survival craft may be effected. The arrangement of the vessel is to be such that all compartments are provided with a satisfactory means of escape.

2 Means of escape from accommodation

2.1

2.1.1 Means of escape are to be provided so that persons onboard can safely and swiftly escape to the liferaft embarkation deck. For the accommodation, two means of escape from every restricted space or group of spaces are to be provided.

2.1.2 The normal means of access to the accommodation and service spaces below the open deck is to be arranged so that it is possible to reach the open deck without passing through a galley, engine room or other space with a high fire risk, wherever practicable.

2.1.3 Where accommodation arrangements are such that access to compartments is through another compartment, the second escape route is to be as remote as possible from the main escape route. This may be through hatches of adequate size leading to the open deck or separate space to the main escape route.

2.1.4 The two means of escape are to be arranged in such a way that a single hazardous event will not cut off both escape routes.

2.1.5 Exceptionally one of the means of escape may be dispensed with, due regard being paid to the nature and location and dimension of spaces and to the number of persons who might normally be accommodated or employed there where in any position the person inside is not more than 5 metres from the exit or for the spaces that may be visited only occasionally In addition efficient fire detectors are to be provided as necessary to give early warning of a fire emergency which could cut off that single means of escape. The escape route is not to pass through a space with fire risk such as a machinery space, galley or space containing flammable liquids

3 Means of escape from machinery spaces

3.1

3.1.1 Means of escape from Category A machinery spaces

Category A machinery spaces on motor vessels are to be provided with a minimum of two means of escape. Other machinery spaces are to also have at least two means of escape as widely separated as possible, except where the small size of the machinery space makes it impracticable

Means of escape from engine room giving direct access to accommodation (cabins, living room, etc) are not allowed.

Whenever a watchman is foreseen in the engine room, the space is to be provided with two escape routes in positions as far apart as possible; one of these routes is to lead to the main deck, through a manhole or a door or a hatchway openable from both sides.

Only 1 means of escape may be accepted for spaces unmanned during normal operation (unmanned machinery spaces are those in compliance with the requirements for the class notation AUT-UMS (Y) - Pt A, Ch 1, Sec 2, [6.2]), and where the single access gives ready escape, at all times, to the open deck in the event of fire.

3.1.2 Means of escape from other spaces

As a general rule two means of escape have to be provided.

In exceptional circumstances a single means of escape may be accepted for spaces, other than accommodation spaces, that are entered only occasionally, if the escape route does not pass through a galley, machinery space or watertight door.

4 Escape route arrangement

4.1

4.1.1 Concealed escapes and escape routes are to be clearly marked to ensure ready exit and clearly identified with appropriate indications. No escape routes are to be obstructed by furniture or fittings

Additionally, furniture along escape routes is to be secured in place to prevent shifting if the yacht rolls or lists.

All doors in escape routes are to be openable from either side. In the direction of escape they are all to be openable without a key.

All handles on the inside of weathertight doors and hatches are to be non-removable.

Where doors are lockable, measures to ensure access from outside the space are to be provided for rescue purposes.

4.1.2 Lifts are not considered as forming a means of escape.

4.1.3 Interior stairways serving machinery spaces, service spaces or control stations are to be of steel or other equivalent material (aluminium alloy suitably insulated). In accommodation spaces, at least one of the two stairways required as means of escape is to be of steel or other equivalent material (aluminum alloy suitably insulated).

4.1.4 All sailing multihulls are to be fitted with an emergency escape hatch in each main inhabited watertight compartment to permit the exit of personnel in the event of an inversion.

Access to the spaces containing the fuel tanks or the engine room is to be from open spaces.

Whenever the fuel oil has a flashpoint > 55Â°C, access may be from a corridor; in no case is direct access to accomodation (cabins, living room, etc.) allowed from spaces containing the fuel tanks or engine room.

4.1.5 One of the exits may be an emergency exit through a small hatchway or through a porthole of dimensions generally not less than 450x450 mm.

SECTION 6 PROTECTION OF SPACES CONTAINING VEHICLES OR CRAFT WITH FUEL IN THEIR TANKS OR LOCKERS STORING SUCH FUELS

1 General

1.1

1.1.1 The requirements of this Section are applicable to spaces containing vehicles or craft with fuel with a flash-point equal to or less than 55° C in their tanks or lockers storing such fuels.

Upon completion of commissioning tests, test reports are to be made available to the Surveyor.

1.2 Open vehicle spaces

1.2.1 Open vehicle spaces are defined as vehicle spaces which are either open at both ends or have an opening at one end and are provided with adequate natural ventilation effective over the entire length through permanent openings distributed in the side plating or deckhead or from above, having a total area that is at least 15% of the total area of the space's sides.

1.3 Weather decks

1.3.1 Weather deck is a deck which is completely exposed to the weather from above and from at least two sides.

1.4 Enclosed vehicle spaces

1.4.1 A space which may be considered neither an open vehicle space nor a weather deck is to be considered as an enclosed vehicle space.

1.5 Non-sparking fans

1.5.1 Non-sparking fans are fans that do not produce sparks in any service condition.

Non-sparking fans are to meet the following requirements:

a) The air gap between the impeller and the casing is to be not less than 1\10 of the shaft diameter in way of the impeller bearing.

   The minimum value of the air gap is, in any case, to be not less than 3 mm, but need not be more than 12 mm.

b) Fan inlets and outlets are to be fitted with flame screens having square mesh not more than 13 mm.

c) The impeller and the housing are to be made with spark-proof materials. Such characteristic is to be certified on the basis of documentation issued by a recognised organisation.

d) Antistatic material is to be adopted in order to prevent electrostatic charges in the rotating body and in the casing.

e) The fans are to be type tested by the Society; alternatively, a Type Approval Certificate issued in conformity with a national or international standard by a recognised organisation may be accepted.

2 Ventilation system

2.1

2.1.1

This paragraph applies only to enclosed vehicle spaces.

A ducted mechanical continuous supply of air ventilation is to be provided, capable of ensuring at least six changes of air per hour in the protected space (based on empty space).

The mechanical ventilation is to be supplied by at least two fans, unless means are available and suitable for use in all weather and navigating conditions, to ventilate the space in case of failure of the fan.

The ventilation system is to be designed as to prevent air stratification and the formation of air pockets.

Means are to be provided in order to shut down the ventilation in the event of fire. Such system is to be fitted outside the space to be ventilated and is to be operated in all the weather and sea conditions.

An alarm is to be provided in the event of a reduction of the rate of ventilation.

The system providing the alarm in the event of a reduction of the rate of ventilation may be based on the check of a reduction of the current supplied to the ventilation motors.

The alarm system is to be powered from the emergency source of electrical power.

The indication is to be fitted on the bridge deck or in another continuously manned position. For small lockers the use of natural ventilation may be evaluated by the Society.

3 Electrical equipment and alarm systems

3.1

3.1.1

For the electrical equipment installed in spaces containing vehicles or craft with fuel in their tanks or lockers storing such fuels see Ch 2, Sec 3, [9.4].

4 Gas detection

4.1

4.1.1

A suitable gas detection system is to be provided, capable of giving an audible and visual alarm on the bridge and in another normally manned position, if any.

At least two gas detectors are to be provided for each monitored space and are to be fitted in the areas where flammable gases are likely to accumulate.

The system is to be declared by the manufacturer as complying with EN Publication 50194-2 or IEC Publication 60079-29-1, as applicable, or with other national or international standards acceptable by the Society.

The system is to be continuously supplied from two circuits, one from the 's main supply and the other from the emergency source of electrical power, where available and is to be provided with an automatic change-over to the standby power supply in case of loss of normal power supply.

Power supplies and electrical circuits necessary for the operation of the system are to be monitored for loss of power or fault condition, as appropriate. Occurrence of a fault condition is to initiate a visual and audible fault signal on the bridge.

5 Smoke detection

5.1

5.1.1 This paragraph applies to enclosed and open vehicle spaces.

A fixed fire detection and fire alarm system complying with the requirements of SOLAS II-2/7 and the IMO Fire Safety Systems Code, Chapter 9 is to be fitted in the vehicle spaces in order to provide smoke detection.

6 Fire extinction

6.1

6.1.1 This paragraph applies to enclosed and open vehicle spaces.

6.1.2 For the fire extinction of the space a water-spraying or sprinkler system designed for 3,5 l/m2 x min is to be fitted. The water-spraying system may be connected to the fire main.

A system providing equivalent protection as determined by the Society may be fitted.

In any case, the system is to be operable from outside the protected space.

6.1.3 In general, if the deck area of the protected space is less than 4 m^2, a carbon portable fire extinguisher sized to provide a minimum volume of free gas equal to 40% of the gross volume of the space may be acceptable in lieu of a fixed system.

The required portable fire extinguisher is to be stowed adjacent to the access door(s).

Alternatively, fire hoses fitted with a jet/spray nozzle can be accepted. The number and distribution of the fire hoses are to be sufficient to ensure that any part of the protected space can be reached by water.

Adequate means are to be provided in order to drain the sprayed water in the space.

Drainage is not to lead to machinery or other spaces where a source of ignition may be present.

7 Boundaries and relevant openings

7.1

7.1.1

The boundaries and relevant openings of the spaces containing vehicles or craft with fuel in their tanks or lockers storing such fuels to other internal spaces are to be reasonably gastight.

8 Bilge system

8.1

8.1.1

The garage is to be drained by a dedicated pump certified safe for flammable liquid.

SECTION 7 REFUEL STATION LOCATED INSIDE A GARAGE CONTAINING VEHICLES OR CRAFTS WITH FUEL IN THEIR TANKS

1 General

1.1

1.1.1 In garage containing vehicles or crafts with fuel in their tanks a refueling stations for fuel with flash point more than 55°C may be installed provided that the following requirements are complied with.

In general, the fuel is to be taken from any storage tank with a suitable dedicated pump located in engine room and a quick closing valve that may be closed from outside the engine room together with the other quick closing valves. Such valves are to be also manually operable. .

1.1.2 In the garage close before the flexible hose of the refueling system a manually operable valve is to be fitted. A label clearly visible from the refueling station is to indicate to close the manually operated valve located in the garage at the end of the refueling operations and empty carefully the part of the system downstream the valve.

1.1.3 The refueling pump and its power supply if located in the engine room and necessary for the operation of the refuel station are to be capable of being stopped locally and also from the garage where the refuel station is fitted.Systems to avoid dripping have to be provided such as a non-combustible cable reel. A dip tray with a draining pipe if possible led to a fuel tank is to be located below the refueling area.

1.1.4 The flexible hose is to have the same fire resistance required for a flexible fuel oil pipe. Adequate ventilation is to be provided during refueling operation, if a mechanical ventilation is not provided the refueling operation has to be carried out with the garage aft or side door open.

1.1.5 Gun, pump and e other fittings (e.g. litre counter…) have to be in accordance with a recognized international standard.

1.1.6 An additional fire extinguisher type EII is to be located close to the refueling area.

SECTION 8 FIRE APPLICATIONS

1 Fire applications

1.1 General requirements

1.1.1 Fire appliances are to be in conformity with Tab 1 and with the requirements of this Section.
The stowage position of fire appliances is to be clearly marked.

1.1.2 The capacity and quantity of the medium are to be in compliance with Tab 2.

Table 1 : Fire appliances

Num	Appliances	Number and specifications
1	Provision of water jet	1 Sufficient to reach any part of the vessel
2	Primary power-driven fire pump	1 The pump is to be driven by the propulsion engines or other different engines
3	Additional independent power-driven fire pump	1 The pump, power source and sea connection are not to be fitted in the same space as the pump listed in item [2]. The capability of this pump is to be not less than 80% of the capability of the pump listed in item [2].
4	Fireman & hydrants	The number of hydrants and the arrangement of the fireman are to be capable of supplying at least one water jet to any point of the yacht with a single length of hose.
5	Hoses - with jet/spray nozzles each fitted with a shut-off facility	at least 2
6	Portable fire extinguishers	At least one portable fire extinguisher is to be fitted for each deck. The type of medium and quantity are to comply with the following items.
7	Fire extinguishers for a machinery space other than cat. A containing internal combustion type machinery	The following appliances are to be provided: a) one portable fire extinguisher type D-II; b) one portable fire extinguisher type F-II.
8	Fire extinguishers in machinery space of category A	a) a fixed fire-extinguishing system in conformity with the requirements of item [3] b) one portable fire extinguisher type D-II; c) one portable fire extinguisher type F-II.
9	Fire extinguishers and appliances in other service spaces	**Radio room or wheelhouse:** 1 portable fire extinguisher type F-II near radio equipment or electrical apparatus; **Galley:** 1 portable fire extinguisher type E-II fitted near the exit; 1 fire blanket **Storerooms:** 1 portable fire extinguisher type E-II fitted near the exit Fire extinguishers of CO_2 type are not permitted in the storerooms

Num	Appliances	Number and specifications
10	Fire extinguisher in sleeping accommodation	1 portable fire extinguisher type E-II for each accommodation space occupied by 4 persons or more close to the entrance and 1 portable fire extinguisher type E-I for each accommodation space occupied by less than 4 persons close to the entrance. In any case 1 portable fire extinguisher for each deck, within 10m of any position within an accommodation or service space. Fire extinguishers of CO2 type are not permitted in accommodation spaces.
11	Fire extinguishers in corridors	1 portable fire extinguisher type D-II for each corridor more than of 5 meter in length and 1 portable fire extinguisher type E-I for each corridor of less than 5 meter. The fire extinguishers required in this row may be the same required in row 10 for accommodation spaces provided that they satisfy both the requirements. Fire extinguishers of CO2 type are not permitted in corridors.
12	Fireman outfit's	1 for yachts of more than 300 GT.

Table 2 : Type and medium capacity

Type	Foam (litres)	Carbon dioxide (kg)	Dry chemical powder (kg)
D-II	9	-	-
E-II	9	5	4
F-II	-	5	4
E-I	6	2	1

2 Fire-extinguishing system

2.1 Fire pumps

2.1.1 Number of fire pumps

Two power-driven fire pumps are to be provided, one of which may be driven by the propulsion system.

2.1.2 The two pumps are to be installed in two different spaces together with their own source of power and sea connection.

2.1.3 Bilge sanitary and general service pumps may be accepted as fire pumps.

2.2 Provision of water jet

2.2.1 When discharging at full capacity through 2 adjacent fire hydrants, the pump is to be capable of maintaining a water pressure of 0.2N/mm^2 at any hydrant, provided the fire hose can be effectively controlled at this pressure.

2.3 Pump capacity

2.3.1 The power-driven fire pump is to have a capacity of:

$2,5 \times \{1+ 0,066 \times (L(B+D))^{0,5}\}^2$ m^3/hour

where:

L is the length

B is the greatest moulded breadth

D is the moulded depth measured to the bulkhead deck amidship.

When discharging at full capacity through 2 adjacent fire hydrants, the pump is to be capable of maintaining a water pressure of 0.2N/mm^2 at any hydrant, provided the fire hose can be effectively controlled at this pressure.

2.3.2 The second fire pump is to have a capacity of at least 80% of that required by [2.3.1] and be capable of input to the fire main. A permanent sea connection, external to the machinery space, is to be provided. 'Throw-over' sea suctions are not acceptable.

2.3.3 Each centrifugal fire pump is to be provided with a non-return valve in the connection to the fire main.

2.3.4 All the mechanical pumps are to be of the self-priming type. If centrifugal pumps are fitted, they are to be provided with a non-return valve in the connection with the fire main.

2.3.5 Each centrifugal fire pump is to be provided with a non-return valve in the connection to the fire main.

2.4 Fire main and hydrants

2.4.1 A fire main, water service pipes and fire hydrants are to be fitted.

2.4.2 The fire main and water service pipe connections to the hydrants are to be sized for the maximum discharge rate of the pump(s) connected to the main.

2.4.3 The fire main, water service pipes and fire hydrants are to be constructed such that they will:

a) not be rendered ineffective by heat;

b) not readily corrode; and

c) be protected against freezing.

2.4.4 The fire main is to have no connections other than those necessary for fire fighting or washing down.

2.4.5 Fire hydrants are to be located for easy attachment of fire hoses, protected from damage and distributed so that a single length of the fire hoses provided can reach any part of the yacht.

2.4.6 Fire hydrants are to be fitted with valves that allow a fire hose to be isolated and removed when a fire pump is operating.

2.4.7 When a fire main is supplied by 2 pumps, 1 in the machinery space and 1 elsewhere, provision is to be made for isolation of the fire main within the machinery space and for the second pump to supply the fire main and hydrants external to the machinery space. Isolation valves are to be manually operated and fitted outside the machinery space in a position easily accessible in the event of a fire.

2.5 Fire hoses

2.5.1 Fire hoses are not to exceed 18 metres in length.

2.5.2 Fire hoses and associated tools and fittings are to be kept in readily accessible and known locations close to hydrants or connections on which they will be used. Hoses supplied from a powered pump are to have jet/spray nozzles (incorporating a shut-off facility) of diameter 19 mm, 16 mm or 12 mm depending on the fire-fighting purposes.

2.5.3 At least one hydrant is to have one hose connected at all times. For use within accommodation and service spaces, proposals to provide a smaller diameter of hoses and jet/spray nozzles will be specially considered.

3 Fixed fire-extinguishing system

3.1

3.1.1 A fixed fire-extinguishing system is to be provided in machinery spaces of category A and in all other machinery spaces containing a fuel oil settling tank or fuel oil unit.

3.1.2

The system is to be in compliance with the IMO FSS CODE and with the requirements given in Annex 2 if carbon dioxide is used as fire extinguishing medium. Systems using other extinguishing medium (e.g. FM200, Novec 1230) may be accepted if certified in accordance with IMO requirements.

3.2 Fire Detection and Fire Fighting system for accommodation, service space, control stations

3.2.1 Each separate zone in all accommodation and service spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc, is to be provided throughout with an automatic sprinkler, fire detection and fire alarm system of an approved type and complying with the requirements of SOLAS, Part C regulation II-2/7 and the IMO FSS Code, Chapter 8, or an equivalent standard accepted by Tasneef. The system is to be designed to enable simultaneous operation of all sprinklers fitted in the most hydraulically demanding area. The minimum area for simultaneous operation may be taken as the largest area bounded by A0 class divisions or the breadth of the vessel squared, whichever is the greater. In addition, a fixed fire detection and fire alarm system of an approved type complying with the requirements of SOLAS II-2/7 and the IMO FSS Code, Chapter 9 is to be installed and arranged to provide smoke detection in corridors, stairways and escape routes within accommodation spaces.

SECTION 9 HELIDECK FACILITIES

1 General

1.1

1.1.1 When provision is made for helicopter operations to/from the vessel, the arrangements are to comply with SOLAS II-2/18 (currently refers to IMO Resolution A.855(20)). Attention is also drawn to the International Civil Aviation Organisation (ICAO) Annex 14 of the Convention on International Civil Aviation, Volume 2 'Heliports'.

1.1.2 As regards helideck facilities, reference is to be made to this Section.
Where helicopters land or conduct winching operations on an occasional or emergency basis on yachts without helidecks, fire-fighting equipment fitted in accordance with the requirements of this Annex may be used. This equipment is to be made readily available in close proximity to the landing or winching areas during helicopter operations.

2 Structural requirements

2.1 Construction of steel or other equivalent materials

2.1.1 As regards helideck scantlings, reference is to be made to Pt B, Ch 9, Sec 10 of Tasneef Rules for the Classification of Ships.

2.1.2 In general, the construction of the helidecks is to be of steel or other equivalent materials. If the helideck forms the deckhead of a deckhouse or superstructure, it is to be insulated to A-30 for yachts having a length greater than 24 m but less than 50 m, or to A-60 class standard for yachts of a length equal to or greater than 50 m.

2.2 Construction of aluminium or other low melting metals

2.2.1 If Tasneef permits aluminium or other low melting point metal construction that is not made equivalent to steel, the following provisions are to be satisfied:

a) if the platform is cantilevered over the side of the yacht, after each fire on the yacht or on the platform, the latter is to undergo a structural analysis to determine its suitability for further use; and

b) if the platform is located above the yacht's deckhouse or similar structure, the following conditions are to be satisfied:

- the deckhouse top and bulkheads under the platform are to have no openings;
- windows under the platform are to be provided with steel shutters; and
- after each fire on the platform or in close proximity, the platform is to undergo a structural analysis to determine its suitability for further use.

3 Means of escape

3.1

3.1.1 A helideck is to be provided with both a main and an emergency means of escape and access for fire-fighting and rescue personnel; these are to be located as far apart from each other as is practicable and preferably on opposite sides of the helideck.

4 Fire-fighting appliances

4.1

4.1.1 In close proximity to the helideck, the following firefighting appliances are to be provided and stored near the means of access to that helideck:

a) at least two dry powder extinguishers having a total capacity of not less than 45 kg

b) carbon dioxide extinguishers of a total capacity of not less than 18 kg or equivalent

c) a suitable foam application system consisting of monitors or foam-making branch pipes capable of delivering foam to all parts of the helideck in all weather conditions in which the helicopter can operate. The system is to be capable of delivering a discharge rate as required in Tab 1 for at least five minutes. The principal agent is to meet the applicable performance standards of the International Civil Aviation Organisation - Airport Services Manual, Part 1 - Rescue and Firefighting, Chapter 8 - Extinguishing Agent Characteristics, Paragraph 8.1.5 - Foam Specifications Table 8-1, Level B foam, and be suitable for use with salt water.

d) at least two nozzles of an approved dual-purpose type (jet/spray) and hoses sufficient to reach any part of the helideck

e) two sets of firemen's outfits; if a helicopter hangar is not provided and if the two firemen's outfits are already supplied, then the fireman's outfits need not be provided; and

f) at least the following equipment, stored in a manner that provides for immediate use and protection from the elements:

- adjustable wrench
- blanket (fire-resistant)
- cutters, bolt 60 cm
- hook, grab or salving
- hacksaw, heavy duty complete with 6 spare blades
- ladder
- lifeline of 5 mm diameter x 15 m in length
- pliers, side cutting
- set of assorted screwdrivers, and
- harness knife complete with sheath.

Table 1 : Foam solution discharge rate

Category	Helicopter overall length	Foam solution discharge rate (litres/min)
H1	less than 15 m	250
H2	at least 15 m but less than 24 m	800
H3	at least 24 m but less than 35 m	500

5 Drainage facilities

5.1

5.1.1 Drainage facilities in way of helidecks are to be constructed of steel and lead directly overboard independent of any other system and designed so that drainage does not fall onto any part of the yacht.

6 Helicopter refuelling and hangar facilities

6.1

6.1.1 Where the yacht has helicopter refuelling and hangar facilities, the following requirements are to be complied with:

a) A designated area is to be provided for the storage of fuel tanks, which is to be:
- as remote as practicable from accommodation spaces, escape routes and embarkation stations, and
- isolated from areas containing a source of vapour ignition.

b) The fuel storage area is to be provided with arrangements whereby fuel spillage may be collected and drained to a safe location.

c) Tanks and associated equipment are to be protected against physical damage and from a fire in an adjacent space or area.

d) Where portable fuel storage tanks are used, special attention is to be given to:
- design of the tank for its intended purpose
- mounting and securing arrangements
- electric bonding, and
- inspection procedures.

e) Storage tank fuel pumps are to be provided with means which permit shutdown from a safe remote location in the event of fire. Where a gravity fuelling system is installed, equivalent closing arrangements are to be provided to isolate the fuel source.

f) The fuel pumping unit is to be connected to one tank at a time. The piping between the tank and the pumping unit is to be of steel or equivalent material, as short as possible, and protected against damage.

g) Electrical fuel pumping units and associated control equipment are to be of a type suitable for the location and potential hazards.

h) Fuel pumping units are to incorporate a device which will prevent over-pressurisation of the delivery or filling hose.

i) Equipment used in refuelling operations is to be electrically bonded.

j) "No smoking" signs are to be displayed at appropriate locations.

k) Hangar, refuelling and maintenance facilities are to be treated as category A machinery spaces with regard to structural fire protection, and fixed fire-extinguishing and detection system requirements.

l) Enclosed hangar facilities or enclosed spaces containing refuelling installations are to be provided with mechanical ventilation as required for spaces containing vehicles or craft with fuel in their tanks, or lockers storing such fuels. Ventilation fans are to be of the non-sparking type.

m) Electrical equipment and wiring in enclosed hangars or closed spaces containing refuelling installations are to comply with the requirements for spaces containing vehicles or craft with fuel in their tanks, or lockers storing such fuels.

7 Operations manual and fire-fighting service

7.1

7.1.1 Each helicopter facility is to have an operations manual, including a description and a checklist of safety precautions, procedures and equipment requirements. This manual may be part of the yacht's emergency response procedures.

7.1.2 The procedures and precautions to be followed during refuelling operations are to be in accordance with recognised safe practices and contained in the operations manual.

8 Fire-fighting service

8.1

8.1.1 Fire-fighting personnel consisting of at least two persons trained for rescue and fire-fighting duties and fire-fighting equipment are to be immediately available at all times when helicopter operations are expected.

8.1.2 Fire-fighting personnel are to be present during refuelling operations. However, the fire-fighting personnel are not to be involved with refuelling activities.

8.1.3 On-board refresher training is to be carried out and additional supplies of fire-fighting media are to be provided for training and for testing of the equipment.

9 Stability

9.1

9.1.1 The stability information booklet is to include a loading condition with the helicopter on deck (for intact stability purposes only).

APPENDIX 1 ALTERNATIVES, RELAXATIONS AND ADDITIONAL CONSIDERATIONS FOR YACHTS BELOW 500 GT

1 Fire prevention (Sec 2)

1.1 General

1.1.1 With reference to Sec 1, [7.1.3] the vapour barrier are to have low flame spread characteristic as far as it is practicable.

2 Fire containment (Sec 3)

2.1 Class divisions

2.1.1 With reference to Sec 3 as an alternative to [3.1.2] to [3.1.5] what below may be applied. For unrestricted yachts category A machinery spaces are to be totally enclosed by A-30 class boundaries. For short range yachts of any gross tonnage, category A machinery spaces are to be enclosed by B-15 class divisions.For unrestricted yachts and for yacht of more than 300GT in short range navigation the galley to be totally enclosed in B-15 class boundaries (bulkheads, side shell and deck heads). Windows within the exterior hull or superstructure within this boundary are not expected to meet "B-15" standards.The above class divisions are not necessary on the side of yachts having the hull structure made of steel.

2.1.2 With reference to Sec 3, [3.2] is not mandatory.

2.2 Ventilating systems

2.2.1 With reference to Sec 3 as an alternative to [4.1.2] what below may be applied. Ventilation ducts serving category A machinery spaces, galleys, spaces containing vehicles or craft with fuel in their tanks, or lockers containing fuel tanks are not to cross accommodation spaces, service spaces or control stations unless the trunking is constructed of steel (minimum thickness 4 mm). The ducting within the accommodation is to be fitted with fire insulation to A-30 (B-15 on short range yachts) to a point at least 5 metres from the machinery space or galley. A material other than steel duly insulated to reach the required A-30 (or B-15 on short range yachts) may be also acceptable

2.3 Sauna

2.3.1 With reference to Sec 3, [3.3.3] what below may be applied. The insulation of sauna may be reduced to A-30.The insulation of sauna may be reduced to B-15 in case of short range yachts.

2.3.2 With reference to Sec 3, [3.3.3] what below may be applied. As an alternative to the automatic sprinkler system, a manual water spray system giving a coverage of 3.5 ltr/m2/min over the total area of the floor may be provided. Such a system may be taken from the fire main or be independent. Electrically driven fire pumps shall be provided with an emergency power supply.

2.4 Steam Room

2.4.1 *(1/1/2025)*
With reference to Sec 3, [3.4.3] in case of yachts of less than 300GT the A-0 class may be replaced by B-0.

3 Means of Escape (Sec 5)

3.1 Means of escape form accommodation

3.1.1 In general the main and emergency means of escape have to be fully independent. In some exceptional situation there can be maximum of 4 meters of shared escape way.

4 Fire applications (Sec 8)

4.1 Fire pumps

4.1.1 With reference to Sec.8 [2.1] and [2.3] the emergency fire pumps may be portable but with fixed sea suction.

4.2 Fire Fighting system for accommodation, service space, control stations

4.2.1 With reference to Sec.8 [3.2] sprinkler system is not mandatory.

APPENDIX 2 ALTERNATIVES, RELAXATIONS AND ADDITIONAL CONSIDERATIONS FOR YACHTS OF LESS THAN 24M LLL

1 Fire prevention (Sec 2)

1.1 General

1.1.1 The requirements set in Sec 2 may applied as far as it is practicable and as a minimum the requirements of EN ISO Standard 9094 have to be applied.

2 Fire containment (Sec 3)

2.1 General

2.1.1 The requirements set in Sec 3 may applied as far as it is practicable and as a minimum the requirements of EN ISO Standard 9094 have to be applied.

3 Fire detection (Sec 4)

3.1 General

3.1.1 The requirements set in Sec.4 may applied as far as it is practicable and as a minimum the requirements of EN ISO Standard 9094 have to be applied.

4 Means of Escape (Sec 5)

4.1 General

4.1.1 The requirements set in Sec.5 may applied as far as it is practicable and as a minimum the requirements of EN ISO Standard 9094 have to be applied.

5 Protection of spaces containing vehicles or craft with fuel in their tanks or lockers storing such fuels (Sec 6)

5.1 General

5.1.1 The requirements set in Sec 6 may applied as far as it is practicable and in particular with reference to ventilation system [2] as a minimum the requirements of EN ISO 11105 have to be applied.

5.1.2 The requirements set in Sec. 6 may applied as far as it is practicable and in particular with reference to gas detection system [4] as a minimum the requirements of EN ISO 50194-2 have to be applied.

5.1.3 The requirements set in Sec. 6 may applied as far as it is practicable as a minimum the requirements of EN ISO 9094 have to be applied.

6 Fire applications (Sec 8)

6.1 Emergency fire pump

6.1.1 With reference to Pt C, Ch 4, Sec 8, [2.1] and [2.3] and Pt C, Ch 4, App 1, [3.1] the emergency fire pump may be hand-operated, provided that it is in compliance with the other requirements of Sec 8, [2.4]. Bilge sanitary and general services pumps may be accepted as fire pumps. Where a hand-operated fire pump is fitted as the additional fire pump, the relevant capacity is to be not less than 1,0 m3/h at 45 strokes/min.

6.2 Fire Fighting system for Machinery Spaces of Cat. A

6.2.1 As an alternative to Sec 8, [3.1] the system may be in compliance with the requirements of ISO Standard 9094. Systems approved in accordance with Chapter 2 of Tasneef “Rules for the Type Approval of Fixed Clean Agent Fire-Extinguishing Systems in Machinery Spaces” or Tasneef “Rules for the type approval of fixed areosol Fire extinguishing system in Machinery Space” are considered as satisfying the requirement of ISO 9094. The system is to be manually activated with a 20 sec time delay.

7 Open flame gas installations (App 3)

7.1 General

7.1.1 The requirements set in App 3 may applied as far as it is practicable and as a minimum the requirements of EN ISO STANDARD 10239 have to be applied.

APPENDIX 3 OPEN FLAME GAS INSTALLATIONS

1 General information

1.1

1.1.1 Possible dangers arising from the use of liquid petroleum gas (LPG) open flame appliances in the marine environment include fire, explosion and asphyxiation, due to leakage of gas from the installation.

1.1.2 Consequently, the siting of gas-consuming appliances and storage containers and the provision of adequate ventilation to spaces containing them are most important.

1.1.3 It is dangerous to sleep in spaces where gas-consuming open flame appliances are left burning, because of the risk of carbon monoxide poisoning.

1.1.4 LPG is heavier than air and, if released, may travel some distance whilst seeking the lowest part of a space. Therefore, it is possible for gas to accumulate in relatively inaccessible areas, such as bilges, and diffuse to form an explosive mixture with air, as in the case of petrol vapour.

1.1.5 A frequent cause of accidents involving LPG installations is the use of unsuitable fittings and improvised 'temporary' repairs.

2 Stowage of gas containers

2.1

2.1.1 LPG cylinders, regulators and safety devices are to be stowed on the open deck (where leakage will not accumulate) or in a compartment above the deck protected from bad weather and solar radiation that is vapour-tight to the vessel’s interior, and fitted with a vent and drain, so that any gas which may leak can disperse overboard.

2.1.2 The vent and drain are to be not less 19 mm in diameter, run to the outside of the craft and terminate 75 mm or more above the 'at rest' waterline. Generally, the drain and locker ventilation is to be 500 mm or more from any opening to the interior.

2.1.3 The cylinders and associated fittings are to be positively secured against movement and protected from damage in any foreseeable event.

2.1.4 Any electrical equipment located in cylinder lockers is to be certified safe for use in the potentially explosive atmosphere.

3 Cylinders and attachments

3.1

3.1.1 Each system is to be fitted with a readily accessible, manually operated isolating valve in the supply pressure part of the system.

3.1.2 In multiple container installations, a non-return valve is to be placed in the supply line near to the stop valve on each container. If a change-over device is used (automatic or manual), it is to be provided with non-return valves to isolate any depleted container.

3.1.3 Where more than one container can supply a system, the system is not to be used with a container removed unless the unattached pipe is fitted with a suitable gas-tight plug arrangement.

3.1.4 Containers not in use or not being fitted into an installation are to have the protecting cap in place over the container valve.

4 Fittings and pipework

4.1

4.1.1

For rigid pipework systems, solid drawn copper alloy or stainless steel tubes are to be used. Steel tubing or aluminium or any materials having a low melting point are not to be used.

4.1.2 Connection between rigid pipe sections is to be made with hard solder (minimum melting point 450ºC). Appropriate compression or screwed fittings are recommended for general use for pipework in LPG installations.

4.1.3 Lengths of flexible piping (if required for flexible connections) are to conform to an appropriate standard, be kept as short as possible, and be protected from inadvertent damage. Such hose is to be installed in such a manner as to give access for inspection along its length.

Proposals for a more extensive use of flexible piping (which conforms to an internationally recognised standard for its application) are to be submitted to the Administration for approval on an individual basis.

5 Appliances

5.1

5.1.1 All appliances are to be well secured to avoid movement.

5.1.2 All unattended appliances are to be of the room sealed type, i.e where the gas flames are isolated in a totally enclosed shield where the air supply and combustion gas outlets are piped to open air.

5.1.3 All gas burners and pilot flames are to be fitted with a flame supervision device which will shut off the gas supply to the burner or pilot flame in the event of flame failure.

5.1.4 Flue-less heaters are to be selected only if fitted with atmosphere-sensitive cut-off devices to shut off the gas supply at a carbon dioxide concentration of not more than 1,5% by volume.

5.1.5 Heaters of a catalytic type are not to be used.

6 Ventilation

6.1

6.1.1 The ventilation requirements of a space containing an LPG appliance are to be assessed against an appropriate standard and are to take into account gas burning equipment and persons occupying that space.

6.1.2 Where ventilators required for the LPG appliances in intermittent use can be closed, there are to be appropriate signs at the appliance warning of the need to have those ventilators open before the appliance is used.

7 Gas detection

7.1

7.1.1 Suitable means for detecting the leakage of gas are to be provided in any compartment containing a gas-consuming appliance, or in any adjoining space of a compartment into which the gas (more dense than air) may seep.

7.1.2 Gas detector heads are to be securely fixed in the lower part of the compartment in the vicinity of the gas-consuming appliance and in other space(s) into which gas may seep. In areas where the detector head is susceptible to damage in the lowest part of the compartment (e.g. engine space bilge), such head is at least to be fitted below the lowest point of ignition.

7.1.3 Any gas detector is preferably to be of a type which will be actuated promptly and automatically by the presence of a gas concentration in air of not greater than 0,5% (representing approximately 25% of the lower explosive limit). The detection system is to incorporate a visible alarm and an audible alarm which can be heard in the space concerned and in the control position with the vessel in operation.

7.1.4 Where electrical detection equipment is fitted, it is to be certified as being flameproof or intrinsically safe for the gas being used.

7.1.5 In all cases, the arrangements are to be such that the detection system can be tested frequently while the vessel is in service; this is to include a test of the detector head operation as well as the alarm circuit, in accordance with the Manufacturers' instructions.

7.1.6 All detection equipment is to be maintained in accordance with the Manufacturers' requirements.

8 Emergency action

8.1

8.1.1 A suitable notice, detailing the action to be taken when an alarm is given by the gas detection system, is to be displayed prominently in the vessel.

8.1.2 The information given is to include the following:

a) The need to be ever alert for gas leakage; and

b) When leakage is detected or suspected, all gas-consuming appliances are to be shut off at the main supply from the container(s) and NO SMOKING is to be permitted until it is safe to do so.

c) NAKED LIGHTS are NEVER to BE USED AS A MEANS OF LOCATING GAS LEAKS.

APPENDIX 4 FIXED GAS FIRE-EXTINGUISHING SYSTEM ADDITIONAL REQUIREMENTS

1 General

1.1

1.1.1 Fixed gas fire-extinguishing systems are to be in compliance with the requirements of Chapter 5 of the FSS Code and with the following additional requirements.

2 System control requirements

2.1

2.1.1 In general, the control valves are to be located within the medium storage room.

2.1.2 The arrangement of means of control, whether mechanical, hydraulic or pneumatic, is to be to the satisfaction of the Society.

3 High pressure carbon dioxide system

3.1 Quantity of fire-extinguishing system

3.1.1 For spaces containing vehicles or craft with fuel in their tanks or lockers storing such fuels, the quantity of carbon dioxide available is, unless otherwise provided, to be sufficient to give a minimum volume of free gas equal to 45% of the gross volume of the largest protected space in the yacht.

3.1.2 For the machinery space, in the calculation of the required 35 per cent of volume, the net volume of the funnel (if any) is to be considered up to a height equal to the whole casing height if the funnel space is in open connection with the machinery space without interposition of closing means.

3.1.3 For spaces containing vehicles or craft with fuel in their tanks or lockers storing such fuels, the fixed piping is to be such that at least 2/3 of the required gas quantity is discharged within 10 minutes (see also Table 1).

Table 1 : Dimensions of the CO_2 piping for the quick discharge *(1/1/2025)*

Diameter	Diameter	CO_2 quantity, in kg	
Nominal D_N (mm)	External d_e (mm)	Machinery spaces	Spaces, other than special category spaces, intended for the carriage of motor vehicles
15	21,3	45	225
20	26,9	100	500
25	33,7	135	675
32	42,4	275	1375
40	48,3	450	2250
50	60,3	1100	5500
65	76,1	1500	7500
80	88,9	2000	10000
90	101,6	3250	16250
100	114,3	4750	23750

Diameter	Diameter	CO_2 quantity, in kg	
Nominal D_N (mm)	External d_e (mm)	Machinery spaces	Spaces, other than special category spaces, intended for the carriage of motor vehicles
110	127,0	6810	34050
125	139,7	9500	47500
150	168,3	15250	76250

3.2 Bottle room

3.2.1 The bottle room/box is to be suitably insulated against any excessive increase in temperature. Doors giving access from the bottle room to accommodation spaces, except for corridors, are not allowed. When in exposed position, the bulkheads and ceiling deck of the bottle room are to be insulated against solar radiation so that the temperature inside the room does not exceed 55°C. For yachts intended to operate in temperate zones, the bottle room temperature may be required to be kept below 45°C, depending on the filling limit accepted for the bottles. Evidence is to be submitted for this purpose. Bottle room/box is to be gas tight. In case the gas quantity in the bottle box is less than 3kg the box need not be gas tight and may be located in a public accommodation spaces provided that:

a) the space has a minimum volume in m^3 so that the percent of CO_2 remain below 1,5% considering the kg of CO_2 contained in the bottle,
b) the space where the box is fitted is suitably ventilated,
c) the box is not easy openable,
d) the box is to be clearly marked,
e) the box is to be provided with an open door alarm in the wheelhouse,
f) the safety valve is to discharge below the lining,
g) the bottle is provided with a low pressure alarm in the wheelhouse or a CO_2 detector is fitted close to the safety valve discharge.

3.3 Bottle arrangement

3.3.1 The bottles are to be arranged in a vertical position and so disposed as to facilitate their weighing. Moreover, in order to avoid corrosion on the bottom of the bottles, they are to be arranged in such a way that ventilation is facilitated and cleaning is possible.

3.4 Bottles and their fittings

3.4.1 The bottles are to be approved by Tasneef on the basis of the requirements of Pt C, Ch 1, Sec 3 of these Rules and are to have a capacity not greater than 67 l. Bottles having capacity up to 80 l may be accepted by Tasneef case-by-case based on satisfactory handling arrangements. In general, the bottles of a particular system are to have the same capacity.

3.4.2 Each bottle is to be provided with a valve recognised as suitable by Tasneef, built in such a way as to avoid the formation of dry ice inside during gas discharge. This valve is to be fitted with a standard threaded connection, for bottle filling, and with a safety device (rupture disk) set to a pressure value between 17 and 20 MPa. The minimum cross-sectional area of the device is to be not less than 50 mm2. The valve is to be fitted with a manual opening control which can be easily and readily operated or with another opening device approved by Tasneef. If the exhaust of the safety devices is led into the CO2 collecting main, or into a proper exhaust pipe leading to the open, Tasneef may waive the requirement for mechanical ventilation of the CO2 room; failing this, the discharge of such safety device is to be equipped with a jet breaker.

3.4.3

The bottles are to be permanently connected to a common collecting main by means of a steel pipe or by a flexible pipe in accordance with [3.4.4]. A non-return valve is to be fitted between each bottle and the collecting main.

3.4.4

Flexible hoses and expansion joints are to be made of materials resistant to the marine environment and to the fluid they are to convey.

Metallic materials are to comply with Ch 1, Sec 9, [2.1].

Flexible hoses are to be designed and constructed in accordance with recognised national or international standards acceptable to Tasneef.

Flexible hoses constructed of rubber or plastic materials are to incorporate a single or double closely woven integral wire braid or other suitable material reinforcement.

Flexible hoses are to be complete with approved end fittings in accordance with the Manufacturer's specification.

End connections that do not have a flange are to comply with Ch 1, Sec 9, [2.3.5] and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose.

The use of hose clamps and similar types of end attachments is not acceptable for flexible hoses in piping systems for carbon dioxide. In other piping systems, the use of hose clamps may be accepted where the working pressure is less than 0,5 MPa and provided there are double clamps at each end connection.

Flexible hoses and expansion joints are to be so designed as to withstand the tests indicated in Ch 1, Sec 9, Tab 26 only for bursting, fire resistance (in accordance with a standard agreed with Tasneef and only for flexible hoses used in the protected space and under pressure), flexibility, elastic deformation, resistance of the material. Flexible hose assemblies are to be selected for the intended location and application taking into consideration ambient conditions, compatibility with fluids under working pressure and temperature conditions consistent with the Manufacturer's instructions.

Type approval tests are to be carried out on flexible hoses or expansion joints of each type and of sizes to be agreed with Tasneef, in accordance with Ch.1, Sec 9, Tab 26 only for bursting, fire resistance, flexibility, elastic deformation, resistance of the material (see also the "Rules for the type approval of flexible hoses and expansion joints").

The flexible hoses or expansion joints subjected to the tests are to be fitted with their connections.

3.5 Safety devices for the CO_2 collecting mains

3.5.1

The CO_2 manifolds located in the bottle room are to be fitted with one or more safety valves or rupture disks set at a pressure value between 17 and 20 MPa with the exhaust pipe led to the open air. The exhaust outlet is to be fitted on the deck in a manner such that the gas flow may not impact on other piping or equipment and is to be directed away from areas where people may be allowed. The outflow cross-sectional area of these valves or rupture disks is to be not less than 300 mm^2. For manifold piping having a nominal diameter less than 25, the cross-sectional area of the safety devices is to be not less than 70% of the relevant manifold cross-sectional area. In any case, it is the responsibility of the manufacturer to ensure that the cross-sectional safety device is adequate for the relevant application. When the exhaust pipe of the bottle safety devices is led into the CO_2 collecting mains, the minimum total outflow cross-sectional area of the safety valves or rupture disks of the CO_2 collecting mains will be given special consideration by Tasneef on a case-by-case basis.

3.6 Carbon dioxide distribution arrangement

3.6.1 The CO_2 distribution system within protected spaces is to be so designed that, when the gas quantity appropriate to that space is discharged, it is uniformly distributed through all the discharge nozzles. In machinery and boiler spaces at least 20 per cent of the required quantity of carbon dioxide is to be discharged below the floor.

3.6.2 The minimum piping diameters for the quick discharge in relation to the quantity of carbon dioxide to be discharged are given in Table 1; different values may be accepted by Tasneef on the basis of the results of detailed hydraulic calculations. For the slow discharge, the piping is to have a nominal diameter, DN, not less than 20 mm. A connection for the compressed air piping is to be provided on the collecting main for the purpose of cleaning the system piping and associated nozzles. This connection is to be threaded and closed with a threaded plug. Alternative means for cleaning the system piping will be considered on a case-by-case basis.

3.6.3 Except as expressly indicated otherwise in Pt C, Ch 1, Sec 9, [2] of these Rules, piping joints are to be made by means of flanges. However, threaded joints may be used within the CO_2 room and within the protected spaces.

3.6.4 The piping, valves and fittings are to be properly secured to the hull structures and, when necessary, they are to be protected against possible damage. Plugs, draining devices and filters, if any, are to be arranged, where necessary, in such a way as to prevent the accumulation of condensation and residues. They are to be situated in easily accessible and controllable positions and, in any case, outside accommodation spaces. For the purpose of reducing friction loss in the piping, the latter is to be arranged as straight as possible and along the shortest path.

3.6.5 The carbon dioxide is to be discharged through nozzles in a nebulised state and for such purpose the utmost care is to be taken in shaping and sizing the nozzle cones to avoid the formation of dry snow or dry ice.

3.6.6 The applicator nozzles are not to be located near ventilation outlets and they are to be clear of machinery or devices which could hinder the outflow. The branch pipes on which the nozzles are fitted are to extend at least 50 mm beyond the last nozzle and are to be closed by a threaded plug in order to allow the removal of any residues left in sections of the piping by the gas flow. The total outflow cross-sectional area of the applicator nozzles in machinery and boiler spaces and in spaces intended for the carriage of motor vehicles is to be not less than 50 per cent or greater than 85 per cent of the outflow cross-sectional area of the carbon dioxide collecting main. In general, the actual outflow cross-sectional area of each applicator is to be between 50 and 160 mm^2 and, in the case of multiple hole applicators, the diameter of each hole is to be not less than 4 mm; different values may be accepted by Tasneef on the basis of the results of detailed hydraulic calculations. Each vehicle or craft with fuel in its tanks or locker storing such fuels is to be fitted with at least 2 applicator nozzles; the distance between two nozzles is generally not to exceed 12 m.

3.7 Alarm devices

3.7.1 In addition to the requirements in Ch 5, (2.13.2) of the FSS Code, the alarm system is to be approved by Tasneef; it may be of the pneumatic type and operating on CO_2, with a delaying device suitable for achieving the required pre-alarm time interval, or of the electrical type.

3.8 Electrical audible alarm

3.8.1 Where the audible alarm in [3.7] above is electrically operated, the following conditions are to be complied with:

a) The supply to the alarm system is to be continuosly powered from the emergency source of electrical power or from a battery suitably located for use in an emergency. An alarm in the event of power failure of the alarm system is to be given in a manned position;

b) Two or more audible alarm devices are to be installed in each protected space, as far away as possible from each other and such that, if one of them goes out of service, the remaining one(s) will be sufficient to give the alarm to the whole space;

c) The circuits supplying the audible alarm devices are to be protected only against short-circuits.

3.8.2 The arrangement of the circuits and their electrical protection are to be such that the failure of one of the audible alarm devices will not impair the operation of the others.

3.8.3 If used for short-circuit protection, the fuses are be of the type fitted with a device indicating the condition.

3.8.4 The electrical cables are to be of the fire-resisting type.

3.8.5 The audible alarm devices and any other equipment located in the space are to be protected within cases ensuring a degree of protection adequate for the space of installation with a minimum of IP44. Where the audible alarm devices and any other equipment are arranged in a hazardous area, the requirements set forth in Pt C, Ch 2, Sec 2, 4.3.1 are to be complied with.

3.9 Pilot bottles

3.9.1 When the simultaneous operation of the bottles is actuated by means of carbon dioxide pressure from a driver bottle, at least two pilot bottles are to be provided, with valves capable of being locally manoeuvred at all times.

The pipes connecting the pilot bottles to the valves of the other bottles are to be of steel and their arrangement is to allow piping distortion due to thermal variations or, failing this, the connection is to be made by means of a flexible pipe recognised as suitable by the Society.

3.10 Shut-off valves

3.10.1 For systems in which bottle valve opening is actuated using the pressure of carbon dioxide discharged from pilot bottles, a valve, normally to be kept shut, is to placed between the main of the pilot bottles and the main of the other bottles. This valve is to be opened by means of the same actuating device as for the pilot bottles and is to be placed upstream of the device delaying the discharge of the non-pilot bottles.

3.11 Materials

3.11.1 The CO_2 system appliances are to be constructed of materials suitable for resisting corrosion from the marine environment; it is recommended that all important fittings of the system are made pf brass, special bronze or stainless steel. The carbon dioxide piping is to be made of steel, hot galvanised inside and outside. The relevant wall thicknesses are to be not less than those specified in Tab 2.

Cast iron connections and fittings are not allowed, except for fittings of ductile or globular cast iron, which may be installed after the distribution valves.

The distribution valves or cocks are to be of such dimensions as to withstand a nominal pressure of not less than 16 MPa. The valves, flanges and other fittings of the piping between the bottles and the distribution valves are to have dimensions for a nominal pressure of not less than 16 MPa.

The valves, flanges and fittings of the piping between the distribution valves and the applicator nozzles are to have dimensions for a nominal pressure of not less than 4 MPa.

Table 2 : Minimum wall thickness for steel pipes for CO_2 fire-extinguishing systems

External diameter of pipes (mm)	Minimum wall thickness (mm)	
	From bottles to distribution station	From distribution station to nozzles
21,3 - 26,9	3,2	2,6
30,0 - 48,3	4,0	3,2
51,0 - 60,3	4,5	3,6
63,5 - 76,1	5,0	3,6
82,5 - 88,9	5,6	4,0
101,6	6,3	4,0
108,0 - 114,3	7,1	4,5
127,0	8,0	4,5
133,0 - 139,7	8,0	5,0
152,4 - 168,3	8,8	5,6

Note 1:

- Pipes are to be galvanised inside and outside. For pipes fitted in the engine room, galvanising may not be required, exclusively at the discretion of the Society.
- For threaded pipes, where allowed, the minimum thickness is to be measured at the bottom of the thread.
- For external diameters larger than those given in the table, the minimum wall thickness will be subject to special consideration by the Society.
- In general, the thicknesses indicated in the table are the nominal wall thickness and no allowance needs to be made for negative tolerance and reduction in thickness due to building.
- The external diameters and thicknesses listed in the table have been selected from ISO standards for welded and seamless steel pipes. For pipes covered by other standards, slightly lower thicknesses may be accepted, at the Society's discretion.

3.12 Inspections and tests

3.12.1

The bottles and associated fittings under pressure are to be subjected to a hydrostatic test pressure of 25 MPa. The piping, valves and other fittings are to be subjected to the following tests witnessed by Tasneef:

a) for those between the bottles and the distribution valves: hydrostatic test to 20 MPa pressure in the workshop before their installation on board and hydrostatic test to 0,7 MPa pressure after their installation on board;

b) for those led through accommodation spaces: hydrostatic test to 5 MPa pressure after their installation on board;

c) for those between the distribution valves and the applicator nozzles: pneumatic test, after their installation on board, to a pressure suitable to check gas-tightness and absence of obstructions;

d) for flexible hoses: hydrostatic test under a pressure at least equal to 1,5 times the maximum service pressure. (see also the Tasneef "Rules for the type approval of flexible hoses and expansion joints" and the relevant requirements given in Ch 1, Sec 9, [2.4]).

3.12.2

The safety devices indicated above in [3.4.2] and [3.5.1] are to be built and tested in compliance with a Recognised International Standard. In this connection, safety devices built and tested in compliance with the ISO 4126 Standard or ASME Code may be accepted.

For each safety device, the manufacturer is to provide a Declaration containing all the technical information to be provided in compliance with the applicable Standard and also attesting that the batch, in which the relevant safety device was included, was tested in compliance with the requirements stated in the relevant reference Standard.

Safety devices accepted by the Society on the basis of the examination of the construction drawings and by testing each batch may also be acceptable. For each batch, a number of safety devices, not less than 10% of the total quantity, are to be tested. A relevant test report will be issued by the Society, and for each safety device included in the said batch the Manufacturer will issue a Declaration attesting that the safety device was included in the batch to which the copy of the test report, attached to the relevant Manufacturer's Declaration, refers.

4 Other systems

4.1

4.1.1 The use of other fixed fire-extinguishing systems will be specially considered by the Society.