Tasneef
هيئة الإمارات للتصنيف
Emirates Classification Society

Rules for the Classification of Yachts Designed for Commercial Use

Effective from 1 January 2023

Part C

Machinery, Electrical Installations, Automation 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 authorised 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 ship builder, 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 ship owner, 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, as for example rule variations or interpretations.

"*Services*" means the activities described in Article 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, as for example offshore structures, floating units and underwater craft.

"*Society*" or *"TASNEEF"* means Tasneef and/or all the companies in the Tasneef Group which provide the Services.

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

Article 1

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 are regulated by these general conditions, unless expressly excluded in the particular contract.

Article 2

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 committed also 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 on the basis of 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. The 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 of 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.

Article 3

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 authorised bodies and for no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties on the basis of 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 in relation to 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, ship builders, 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 in relation to 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 with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

Article 4

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. In the event of late payment, interest at the legal current rate increased by 1.5% may be demanded.

4.3. The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.
For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed 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 the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

Article 5

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 art. 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.
Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

5.2. Notwithstanding the provisions in paragraph 5.1 above, should any user of the Society's Services prove that he has suffered a loss or damage due to any negligent act or omission of the Society, its Surveyors, servants or agents, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fees charged for the specific services, information or opinions from which the loss or damage derives or, if no fee has been charged, a maximum of AED5,000 (Arab Emirates Dirhams Five Thousand only). Where the fees charged are related to a number of Services, the amount of the fees will be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of the Service from which the damage or loss derives. Any liability for indirect or consequential loss, damage or expense is specifically excluded. In any case, irrespective of the amount of the fees charged, the maximum damages payable by the Society will not be more than AED5,000,000 (Arab Emirates Dirhams Five Millions only). Payment of compensation under this paragraph will not entail any admission of responsibility and/or liability by the Society and will be made without prejudice to the disclaimer clause contained in paragraph 5.1 above.

5.3. Any claim for loss or damage of whatever nature by virtue of the provisions set forth herein shall be made to the Society in writing, within the shorter of the following periods: (i) THREE (3) MONTHS from the date on which the Services were performed, or (ii) THREE (3) MONTHS from the date on which the damage was discovered. Failure to comply with the above deadline will constitute an absolute bar to the pursuit of such a claim against the Society.

Article 6

6.1. These General Conditions shall be governed by and construed in accordance with United Arab Emirates (UAE) law, and any dispute arising from or in connection with the Rules or with the Services of the Society, including any issues concerning responsibility, liability or limitations of liability of the Society, shall be determined in accordance with UAE law. The courts of the Dubai International Financial Centre (DIFC) shall have exclusive jurisdiction in relation to any claim or dispute which may arise out of or in connection with the Rules or with the Services of the Society.

6.2. However,

(i) In cases where neither the claim nor any counterclaim exceeds the sum of AED300,000 (Arab Emirates Dirhams Three Hundred Thousand) the dispute shall be referred to the jurisdiction of the DIFC Small Claims Tribunal; and

(ii) for disputes concerning non-payment of the fees and/or expenses due to the Society for services, the Society shall have the right to submit any claim to the jurisdiction of the Courts of the place where the registered or operating office of the Interested Party or of the applicant who requested the Service is located.

In the case of actions taken against the Society by a third party before a public Court, the Society shall also have the righ t to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

Article 7

7.1. 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 authorisation 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 cl ass, 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.

7.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's c lients 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 propert y 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.

7.3. 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, certificat es, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty t o ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of 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.

Article 8

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

EXPLANATORY NOTE TO PART C

1. Reference edition

The reference edition of these Rules is the edition effective from 1 January 2015.

2. Effective date of the requirements

2.1 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.

2.2 Item 5 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.

3. 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.

4. Rule subdivision and cross-references

4.1 Rule subdivision

The Rules are subdivided into five parts, from A to E.

Part A: Classification and Surveys

Part B: Hull and Stability

Part C: Machinery, Electrical Installations, Automation and Fire Protection

Part D: Materials and Welding

Part E: 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.

4.2 Cross-references

Examples: Pt A, Ch 3, Sec 1, [3.2.1] or Pt A, Ch 3, 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 3 means Chapter 3

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.

5. Summary of amendments introduced in the edition effective from 1 January 2020

Foreword

This edition of the Rules for the classification of Yachts Designed for Commercial Use contains amendments whose effective date is **1 January 2020**.

The date of entry into force of each new or amended item is shown in brackets after the number of the item concerned.

RULES FOR THE CLASSIFICATION OF YACHTS DESIGNED FOR COMMERCIAL USE

Part C
Machinery, Electrical Installations, Automation and Fire Protection

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Chapter 1 **MACHINERY**

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Part C

Machinery, Electrical Installations, Automation and Fire Protection

Chapter 1

MACHINERY

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SECTION 13	REFRIGERATING INSTALLATIONS
SECTION 14	TESTS ON BOARD
APPENDIX 1	PLASTIC PIPES

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 Documentation to be submitted

1.2.1 Before the actual construction is commenced, the Manufacturer, Designer or ship builder is to submit to Tasneef 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.

Tasneef 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.

Unless otherwise stated in the other Sections of this Chapter or agreed with Tasneef documents for approval are to be sent in triplicate if submitted by the shipyard and in four copies if submitted by the equipment supplier.

In any case, Tasneef reserves the rights to require additional copies when deemed necessary.

1.3 Definitions

1.3.1 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 fuel oil unit, or
- gas generators, incinerators, waste disposal units, etc., which use oil fired equipment.

1.3.2 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.

1.3.3 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.

2 Design and construction

2.1 General

2.1.1 The machinery, boilers and other 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 are to be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards.

The design is to have regard to 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 Tasneef 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, or
- 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 will not cause undue stresses in this machinery in the normal operating ranges.

2.4 Ambient conditions

2.4.1 Machinery and systems covered by the Rules are to be designed to operate properly under the ambient conditions specified in Tab 1, unless otherwise specified in each Section of this Chapter.

2.5 Power of machinery

2.5.1 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 rated power/rotational speed declared by the Manufacturer according to a recognised standard
- for auxiliary machinery, the power/rotational speed which is available in service.

2.6 Astern power

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

For main propulsion systems with reversing gears, controllable pitch propellers or electric 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 14).

2.7 Safety devices

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

2.7.2 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 are to be provided, where practicable, to protect against such excessive pressure.

2.7.3 Main turbine propulsion machinery and, where applicable, main internal combustion propulsion machinery and auxiliary machinery are to 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.

Tasneef may permit provision for overriding automatic shut-off devices.

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

Table 1 : Ambient conditions

AIR TEMPERATURE	
Location, arrangement	Temperature range (°C)
In enclosed spaces	between 0 and +45 **(2)**
On machinery components 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 Tasneef in the case of yachts intended for restricted service.

2.8 Fuels

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

2.8.2 For yachts having fuel oil with a flashpoint below 43°C the arrangments for the storage, distribution and utilisation of the fuel oil are to be such that the safety of the craft and persons on board is preserved, having regard to fire and explosion hazard. The arrangments are to comply with Ch 2, Sec 3, [9].

Tanks for the storage of such fuel oil are to be located outside any machinery space and at a distance of not less than 760 mm inboard from the shell and bottom plating and from decks and bulkheads.

The spaces in which such fuel oil tanks are located are to be mechanically ventilated using exhaust fans providing not less than six air changes per hour. The fans are to be such as to avoid the possibility of ignition of flammable gas air mixture. Suitable wire mesh guards are to be fitted over inlet and outlet ventilation openings. The outlets for such exhaust are to discharge to a safe position.

A fixed vapour detection system is to be installed in each space through which fuel oil lines pass, with alarms provided at a continously manned control station.

2.9 Use of asbestos

2.9.1 *(1/1/2016)*
New installation of materials which contain asbestos is prohibited.

2.10 Operation in inclined position

2.10.1 *(1/1/2016)*
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 2.

The Society may permit deviations from angles given in Tab 2, 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 alongships. If this is not possible, the Manufacturer is to be informed at the time the machinery is ordered.

Table 2 : Inclination of yacht *(1/1/2016)*

Installations, components	Angle of inclination (degrees) **(1)**			
	Athwart ship		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) Up to an angle of inclination of 45° no undesired switching operations or operational changes may occur
(3) Where the length of the yacht exceeds 100m, the fore-and-aft static angle of inclination may be taken as 500/L degrees, where L is the length of yacht, in metres, as defined in Pt B, Ch 1, Sec 2, [4.2.1].

3 Arrangement and installation on board

3.1 General

3.1.1 Provision is to 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 in general 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 6).

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 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, a sufficient supply of air is maintained to the spaces for the operation of the machinery.

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 requirements of the engine Manufacturer are to be complied with.

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

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. exhaust gas lines, silencers 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.

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

3.8 Communications

3.8.1 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.

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

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

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.

4 Tests and trials

4.1 Works tests

4.1.1 Works tests for equipment and its components for ? class notation assignment are detailed in the relevant Sections of this Chapter.

Where such tests cannot be performed in the workshop, Tasneef 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 regarding incomplete tests.

All parts of machinery, all hydraulic, pneumatic and other systems and their associated fittings which are under internal pressure are to 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 14.

SECTION 2 DIESEL ENGINES

1 General

1.1 Application

1.1.1 Diesel engines when intended for yachts to be assigned the ✠ **MACH notations** and 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 Tasneef Surveyors:

a) main propulsion engines

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

All other engines and the engines when intended for yachts to be assigned the ● **MACH notation** are to be designed and constructed according to sound marine practice, with the equipment required in [2.1.3], and delivered with the relevant works' certificate (see Pt D, Ch 1, Sec 1, [4.2.3]).

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

1.2 Documentation to be submitted

1.2.1 The Manufacturer is to submit to Tasneef the documents listed in Tab 1.

Where changes are made to an engine type for which the documents listed in Tab 1 have already been examined or approved, the engine Manufacturer is to resubmit to Tasneef updated documents.

1.3 Definitions

1.3.1 Engine type

In general, the type of an engine is defined by the following characteristics:

- the cylinder diameter
- the piston stroke
- the method of injection (direct or indirect injection)
- the kind of fuel (liquid, gaseous or dual-fuel)
- the working cycle (4-stroke, 2-stroke)
- the gas exchange (naturally aspirated or supercharged)
- the maximum continuous power per cylinder at the corresponding speed and/or brake mean effective pressure corresponding to the above-mentioned maximum continuous power
- the method of pressure charging (pulsating system or constant pressure system)
- the charging air cooling system (with or without intercooler, number of stages, etc.)
- cylinder arrangement (in-line or V-type).

1.3.2 Engine powers

The maximum power is the power at ambient reference conditions (see Sec 1, [2.4.1]) which the engine is capable of delivering continuously, at nominal maximum speed, in the period of time between two consecutive overhauls.

The rated power is the maximum power at ambient reference conditions (see Sec 1, [2.4.1]) which the engine is capable of delivering as set after works trials (fuel stop power) at the maximum speed allowed by the governor.

Power, speed, service profile and the period of time between two consecutive overhauls are to be stated by the Manufacturer and agreed by Tasneef

The rated power for engines driving electric generators is the nominal power, taken net of overload, at ambient reference conditions (see Sec 1, [2.4.1]), which the engine is capable of delivering as set after the works trials; see [4.2].

The difference between the maximum continous power and the rated power will be considered on a case-by-case basis.

Table 1 : Documentation to be submitted

No	I/A **(1)**	Document	Document details
1	I	Engine particulars as per Tasneef form "Particulars of diesel engines" or equivalent form including the material specification for the main parts	-
2	I	Engine outline	
3	I	Crankcase explosion relief valve arrangements **(2)** (see also [2.1.3])	Volume of crankcase and other spaces (camshaft drive, scavenge, etc.)
4	I	Operation and service manuals	-

(1) A = to be submitted for approval in four copies
I = to be submitted for information in triplicate.
(2) Required only for engines with cylinder bore of 200 mm and above or crankcase gross volume of 0,6 m^3 and above.

1.3.3 Same type of engines

Two diesel engines are considered to be of the same type when they do not substantially differ in design and construction characteristics, such as those listed in the engine type definition as per [1.3.1], it being taken for granted that the documentation concerning the essential engine components listed in [1.2] and associated materials employed has been submitted, examined and, where necessary, approved by Tasneef

2 Design and construction

2.1 Crankcase

2.1.1 Strength

The scantlings of crankcases and crankcase doors are to be designed to be of sufficient strength, and the doors are to be securely fastened so that they will not be readily displaced by an explosion.

2.1.2 Ventilation and drainage

The ventilation of crankcases, or any other arrangement which may produce an inrush of air, is in principle prohibited.

Vent pipes, where provided, are to be as small as practicable. If provision is made for the forced extraction of gases from the crankcase (e.g. for detection of explosive mixtures), the vacuum in the crankcase is not to exceed $2,5.10^4$ MPa.

Where two or more engines are installed, their vent pipes and lubricating oil drain pipes are to be independent to avoid intercommunication between crankcases.

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

2.1.3 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 of a suitable type with sufficient relief area according to the requirements of this item [2.1.3].

   The relief valves are to be arranged or provided with suitable means to ensure that discharge is so directed as to minimise the possibility of injury to personnel.

   The volume of the fixed parts in the crankcase may be deducted when estimating the crankcase gross volume.

   The relief valves are to be of the spring-loaded type capable of quickly relieving the overpressure in the event of an internal explosion and closing immediately thereafter to prevent any inrush of air.

   The valves are to be designed and constructed to open quickly at a pressure not greater than 0,02 MPa and to close quickly and automatically in order to avoid an inrush of air in the crankcase.

   They are to be of an approved type.

   The valve covers are to be of metallic ductile material able to withstand the impact of the stops at the end of the lift.

   The discharge from the valves is to be properly shielded in order to reduce the possible danger from emission of flame.

b) 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 exceeding 250 mm, 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.

   Additional 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.

c) 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.

   The volume of the fixed parts in the crankcase may be deducted in estimating the gross volume.

2.2 Systems

2.2.1 General

In addition to the requirements of the present item, those given in Sec 9 are to be satisfied.

2.2.2 Fuel oil system

In fuel oil systems for propulsion machinery, filters and water separators are to be fitted.

2.2.3 Lubricating oil system

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

Relief valves 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.

2.3 Starting air system

2.3.1 The requirements given in [3.1] apply.

2.4 Control and monitoring

2.4.1 General

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

2.4.2 Alarm

The lubricating oil system of diesel engines 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.

2.4.3 Governors of main and auxiliary diesel engines

Each engine, except the auxiliary engines for driving electric generators for which [2.4.5] applies, is to be fitted with a speed governor so adjusted that the engine does not exceed a safe speed.

2.4.4 Overspeed diesel protective devices of main and auxiliary engines

In addition to the speed governor, each engine having a rated power of 220kW and above, 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 Tasneef in each case.

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

2.4.5 Governors for auxiliary engines driving electric generators

a) Auxiliary engines intended to drive electric generators are to be fitted with a speed governor which prevents any transient speed variations in excess of 10% of the rated speed when the rated power is suddenly thrown off or specific loads are suddenly thrown on.

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) Emergency generator sets must satisfy the governor conditions as per items a) and b) even when total emergency load is applied suddenly.

d) 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.

2.4.6 Use of electronic governors

a) Electronic governors for main propulsion diesel engines

   A fault in the governor system is not to lead to sudden increase in propulsion power.

b) 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".

2.4.7 Summary tables

Diesel engines installed on all yachts are to be equipped with monitoring equipment as detailed in Tab 2 and Tab 3, for main propulsion and auxiliary services, respectively.

The acceptance of a reduction in the monitoring equipment required in Tab 2 and Tab 3 may be considered.

The alarms are to be visual and audible.

The indicators are to be fitted at a normally attended position.

Table 2 : Monitoring of main propulsion diesel engines

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	Slowdown	Shutdown	Control	Standby Start	Stop
Lubricating oil pressure	L						
Lubricating oil temperature		X					
Cylinder fresh cooling water temperature	H	X					
Exhaust gas temperature		X **(1)**					
Engine speed / direction of speed (when reversible)		X					
				H **(1)**			
Fault in the electronic governor system	X						
(1) Indication is required for engines of 1000 kW and above							

Table 3 : Monitoring of diesel engines used for auxiliary services

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	Indica-tion	Slow-down	Shut-down	Control	Standby Start	Stop
Lubricating oil pressure	L						
Temperature of cooling water or cooling air		local					

3 Arrangement and installation

3.1 Starting arrangements

3.1.1 Mechanical air starting *(1/1/2023)*

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 6 consecutive starts of one engine and 2 additional starts for each of the other engines.

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 5, 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:

1) An isolating non-return valve, or equivalent, at the starting air supply connection to each engine.

2) 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 Tasneef

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

e) Compressed air receivers are to comply with the requirements of Sec 3. Compressed air piping and associated air compressors are to comply with the requirements of Sec 9.

3.1.2 Electrical starting

a) Where main internal combustion engines are arranged for electrical starting, at least two separate sets of 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 [3.1.1] (b) in the event of air starting.

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

c) One of the starting batteries is 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.

3.1.3 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 Tasneef is to be made for the maintenance of heating arrangements, to ensure ready starting of the generating sets.

b) Each emergency generating set arranged to be automatically started is to be equipped with starting devices approved by Tasneef with a stored energy capability of at least three consecutive starts.

c) The stored energy is to be maintained at all times, as follows:
   - electrical and hydraulic starting systems are to 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) 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.

3.2 Trays

3.2.1 Trays or equivalent means 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.

3.3 Exhaust gas system

3.3.1 In addition to the requirements given in Sec 9, 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]).

4 Material tests, workshop inspection and testing, certification

4.1 Material and non-destructive tests

4.1.1 Material tests

Part of engines, to be qualified for assignment of the ✠ **MACH notation** 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 Tasneef Surveyor, where experience shows defects are most likely to occur.

Table 4 : Material and non-destructive tests

Engine component	Material tests **(1)** (Mechanical properties and chemical composition)	Non-destructive tests	
		Magnetic particle or liquid penetrant	Ultrasonic
1) Crankshaft	all	all	all
2) Crankshaft coupling flange (non-integral) for main power transmissions	if bore > 400 mm	-	-
3) Coupling bolts for crankshaft	if bore > 400 mm	-	-
4) Steel piston crowns **(2)**	if bore > 400 mm	if bore > 400 mm	all
5) Piston rods	if bore > 400 mm	if bore > 400 mm	if bore > 400 mm
6) Connecting rods, together with connecting rod bearing caps	all	all	if bore > 400 mm
7) Crossheads	if bore > 400 mm	-	-
8) Cylinder liners	if bore > 300 mm	-	-
9) Steel cylinder covers **(2)**	if bore > 300 mm	if bore > 400 mm	all
10) Bedplates of welded construction; plates and transverse bearing girders made of forged or cast steel **(2) (3)**	all	all	all
11) Frames and crankcases of welded construction **(3)**	all	-	-
12) Entablatures of welded construction **(3)**	all	-	-
13) Tie rods	all	if bore > 400 mm	-
14) Shafts and rotors, including blades, for turbochargers **(4)**	(see Sec 14)	-	-

Engine component	Material tests (1) (Mechanical properties and chemical composition)	Non-destructive tests	
		Magnetic particle or liquid penetrant	Ultrasonic
15) Bolts and studs for cylinder covers, crossheads, main bearings and connecting rod bearings; nuts for tie rods	if bore > 300 mm	if bore > 400 mm	-
16) Steel gear wheels for camshaft drives	if bore > 400 mm	if bore > 400 mm	-

(1) In addition, material tests may also be required, at Tasneef discretion, for piping and valves for starting air lines and any other pressure piping fitted on the engines.
(2) For items 4), 9) and 10), it is implicit that as well as for steel parts, material tests are also required for parts made of other materials which are comparable to steel on account of their mechanical properties in general and their ductility in particular: e.g. aluminium and its alloys, ductile and spheroidal or nodular graphite cast iron.
(3) Material tests for bedplates, frames, crankcases and entablatures are required even if these parts are not welded and for any material except grey cast iron.
(4) Turbocharger is understood as the turbocharger itself and the engine driven compressor (incl. "Root blowers", but not auxiliary blowers).

The magnetic particle test of tie rods/stay bolts is to be carried out at each end, for a portion which is at least twice the length of the thread.

For important structural parts of engines, 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 engine component, non-destructive tests using approved detecting methods may be required.

Engines of a cylinder diameter not exceeding 300 mm may be tested according to an alternative survey scheme.

4.1.2 Hydrostatic tests

Parts of engines under pressure are to be hydrostatically tested at the test pressure specified for each part in Table 5.

The following parts of auxiliaries which are necessary for operation of engines as per [1.1.1] a) and b):

- cylinders, cylinder covers, coolers and receivers of independent air compressors
- water, oil and air coolers (tube bundles or coils, shells and heads) not fitted on the engine and filters
- independently driven lubricating oil, fuel oil and water pumps
- pressure pipes (water, lubricating oil, fuel oil and compressed air pipes), valves and other fittings

are to be subjected to hydrostatic tests at 1,5 times the maximum working pressure, but not less than 0,4 MPa.

4.2 Workshop inspections and testing

4.2.1 General

Diesel engines are to be subjected to works trials, which are to be witnessed by the Surveyor except where an Alternative Inspection Scheme has been granted or where otherwise decided by Tasneef on a case-by-case basis.

For all stages at which the engine is to be tested, the relevant operating values are to be measured and recorded by the engine Manufacturer.

Table 5 : Test pressure of engine parts

Parts under pressure		Test pressure (MPa) (1) (2)
1	Cylinder cover, cooling space (3)	0,7
2	Cylinder liner, over the whole length of cooling space	0,7
3	Cylinder jacket, cooling space	0,4 (but not less than 1,5 p)
4	Exhaust valve, cooling space	0,4 (but not less than 1,5 p)
5	Piston crown, cooling space (3) (4)	0,7
6	Fuel injection system a) Fuel injection pump body, pressure side b) Fuel injection valve c) Fuel injection pipes	 1,5 p (or p + 30, if lesser) 1,5 p (or p + 30, if lesser) 1,5 p (or p + 30, if lesser)
7	Hydraulic system • Piping, pumps, actuators etc for hydraulic drive of valves	 1,5 p
8	Scavenge pump cylinder	0,4

Parts under pressure		Test pressure (MPa) **(1)** **(2)**
9	Turbocharger, cooling space	0,4 (but not less than 1,5p)
10	Exhaust pipe, cooling space	0,4 (but not less than 1,5 p)
11	Engine driven air compressor (cylinders, covers, intercoolers and aftercoolers) a) Air side b) Water side	 1,5 p 0,4 (but not less than 1,5 p)
12	Coolers, each side **(5)**	0,4 (but not less than 1,5 p)
13	Engine driven pumps (oil, water, fuel, bilge)	0,4 (but not less than 1,5 p)

(1) In general, parts are to be tested at the hydraulic pressure indicated in the table. Where design or testing features may call for modification of these test requirements, special consideration will be given by Tasneef
(2) p is the maximum working pressure, in MPa, in the part concerned.
(3) For forged steel cylinder covers and forged steel piston crowns, test methods other than hydrostatic testing may be accepted, e.g. suitable non-destructive tests and documented dimensional tests.
(4) Where the cooling space is sealed by the piston rod, or by the piston rod and the shell, the pressure test is to be carried out after assembly.
(5) Turbocharger air coolers need to be tested on the water side only.

In each case all measurements conducted at the various load points are to be carried out under steady operating conditions.

The readings for 100% of the rated power P at the corresponding speed n are to be taken twice at an interval of at least 30 minutes.

At the discretion of the Surveyor, the program of trials given in [4.2.2], [4.2.3] or [4.2.4] may be expanded depending on the engine application.

4.2.2 Main propulsion engines driving propellers

Main propulsion engines are to be subjected to trials to be performed as follows:

a) at least 60 min, after having reached steady conditions, at rated power P and rated speed n

b) 30 min, after having reached steady conditions, at 110% of rated power P and at a speed equal to 1,032 of rated speed

c) tests at 90% (or normal continous cruise power), 75%, 50% and 25% of rated power P, carried out:
- at the speed corresponding to the nominal (theoretical) propeller curve, for engines driving fixed pitch propellers
- at constant speed, for engines driving controllable pitch propellers

d) idle run

e) starting and reversing tests (when applicable)

f) testing of the speed governor and of the independent overspeed protective device

g) testing of alarm and/or shutdown devices.

Note 1: After running on the test bed, the fuel delivery system is to be so adjusted that the engine cannot deliver more than 100% of the rated power at the corresponding speed.

4.2.3 Engines driving electric generators used for main propulsion purposes

Engines driving electric generators are to be subjected to trials to be performed with a constant governor setting, as follows:

a) at least 60 min, after having reached steady conditions, at 100% of rated power P and rated speed n

b) 45 min, after having reached steady conditions, at 110% of rated power and rated speed

c) 75%, 50% and 25% of rated power P, carried out at constant rated speed n

d) idle run

e) starting tests

f) testing of the speed governor ([2.4.5]) and of the independent overspeed protective device (when applicable)

g) testing of alarm and/or shutdown devices.

Note 1: After running on the test bed, the fuel delivery system of diesel engines driving electric generators is to be adjusted such that overload (110%) power can be produced but not exceeded in service after installation on board, so that the governing characteristics, including the activation of generator protective devices, can be maintained at all times.

4.2.4 Engines driving auxiliary machinery

Engines driving auxiliary machinery are to be subjected to the tests stated in [4.2.2] or [4.2.3] for variable speed and constant speed drives, respectively.

Note 1: After running on the test bed, the fuel delivery system of diesel engines driving electric generators is to be adjusted such that overload (110%) power can be produced but not exceeded in service after installation on board, so that the governing characteristics, including the activation of generator protective devices, can be fulfilled at all times.

4.2.5 Inspection of engine components

After the works trials, several components are to be selected for inspection by the Manufacturer or by the Surveyor if the works trials are witnessed.

4.2.6 Parameters to be measured

The data to be measured and recorded, when testing the engine at various load points, are to include all necessary parameters for engine operation. The crankshaft deflection is to be verified when this check is required by the Manufacturer during the operating life of the engine.

4.2.7 Test report

In the test report for each engine the results of the tests carried out are to be compiled; the test report is to be issued by the Manufacturer and enclosed with the testing certificate.

4.3 Certification

4.3.1 Testing certification

a) Engines admitted to an alternative inspection scheme

   For Manufacturers admitted to the alternative inspection the requested certificates are specified in the agreed scheme.

b) Engines not admitted to an alternative inspection scheme

   Tasneef certificates (C) (see Pt D, Ch 1, Sec 1, [4.2.1]) are required for material tests of components in Tab 4 and for works trials as per [4.2].

   Works' certificates (W) (see Pt D, Ch 1, Sec 1, [4.2.3]) are required for non-destructive and hydrostatic tests of components in Tab 4 and Tab 5.

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

- engine type
- rated power
- rated speed
- driven equipment
- operating conditions
- list of auxiliaries fitted on the engine.

4.4 Type approved engine

4.4.1 Issue of Tasneef Type Approval Certificate *(1/1/2019)*

For yachts less than 500 GT, when ✠ **MACH** class notation is to be assigned, the engines defined in [1.1.1] a) and b) as an alternative may be type approved by Tasneef

For a particular type of engine, 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 [4.1] and [4.2].

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.

4.4.2 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 Tasneef

SECTION 3 PRESSURE VESSELS

1 General

1.1 Application

1.1.1 Pressure vessels not covered by the Rules *(1/1/2017)*

This Section is not applicable to pressure vessels of class 3 (as specified in [1.3]), having design pressure $p \le 1$ MPa and product $p\ V \le 150$ (V being the internal volume, in dm^3, 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.

1.2 Definitions

1.2.1 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.

1.2.2 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.

1.2.3 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.

1.2.4 Design temperature

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

1.2.5 Ductile material

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

1.3 Classes

1.3.1 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

1.4 Alternative standards

1.4.1

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 Tasneef on a case-by-case basis.

1.5 Documentation to be submitted

1.5.1 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 1 : Pressure vessel classification

Equipment	class 1	class 2	class 3
Pressure vessels and heat exchangers	$p > 4$ MPa, or $t_A > 40$ mm, or $T > 350^oC$	$1,75 < p \le 4$ MPa, or $15 < t_A \le 40$ mm, or $150 < T \le 350^oC$, 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, irrespective of the values of the other characteristics.			

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 in four copies I = to be submitted for information in duplicate		

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 to special consideration by Tasneef

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 to which [2.2.1] applies.

Spheroidal cast iron may be used subect to the agreement of Tasneef 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 pressure vessels constructed in accordance with one of the standards considered acceptable by Tasneef as per [1.4], the material specifications are to be in compliance with the requirements of the standard used.

2.2 Access arrangement

2.2.1

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 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, 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) may not 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 [3.4.7], as applicable.

c) In pressure vessels where an access manhole cannot be fitted, at least the following openings are to be provided, as far as practicable:
   - Head holes: minimum dimensions: 220 mm x 320 mm (320 mm diameter if circular)
   - Handholes: minimum dimensions: 87 mm x 103 mm
   - 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.

2.3 Safety valves

2.3.1

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.

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%.

2.4 Protection of heat exchangers

2.4.1 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.

2.5 Corrosion protection

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

2.6 Drainage

2.6.1

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.

2.7 Marking

2.7.1

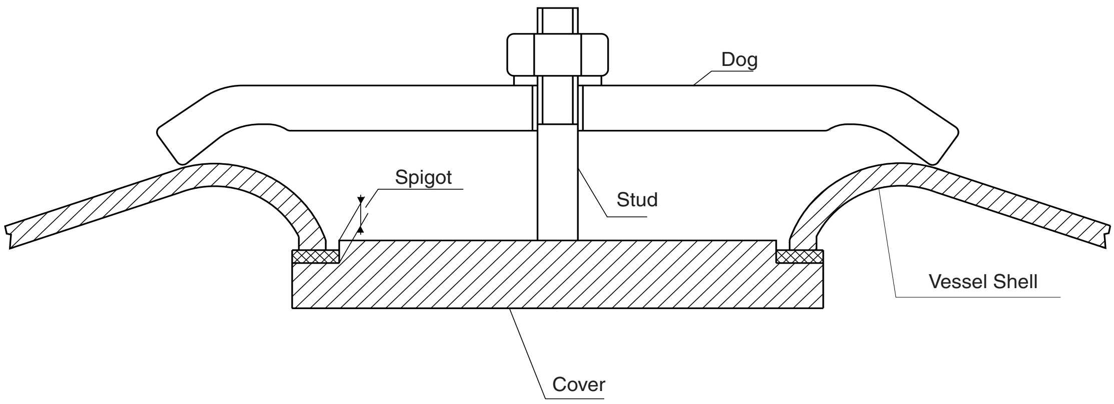
a) Each pressure vessel is to be fitted with a permanently attached plate made of non-corrosive metal, with indication of the following information, in addition to the identification marks (name of Manufacturer, year and serial number):
   - the design pressure
   - the design temperature
   - the test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

d) Each seamless pressure vessel 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.

Figure 1 : Opening cover



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, Tasneef 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 Tasneef

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 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 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/mm²

$R_{S,MIN,T}$: Minimum between R_{eH} and $R_{p\ 0,2}$ at the design temperature T, in N/mm²

S_A : Average stress to produce creep rupture in 100000 hours, in N/mm², at the design temperature T

A : Safety factor taken as follows, when reliability of $R_{S,MIN,T}$ and S_A values is proved to Tasneef satisfaction:

- 1,5 for pressure vessels
- specially considered by Tasneef 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 down to 10% may be taken into consideration by Tasneef

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/mm²

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/mm²

f) Additional conditions:

- In special cases Tasneef 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 Tasneef 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/mm², 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 the 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 the 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 the subject of special consideration by Tasneef

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
(1) In special cases Tasneef reserves the right to take a factor e < 1, depending on the welding procedure adopted for the welded joint.	

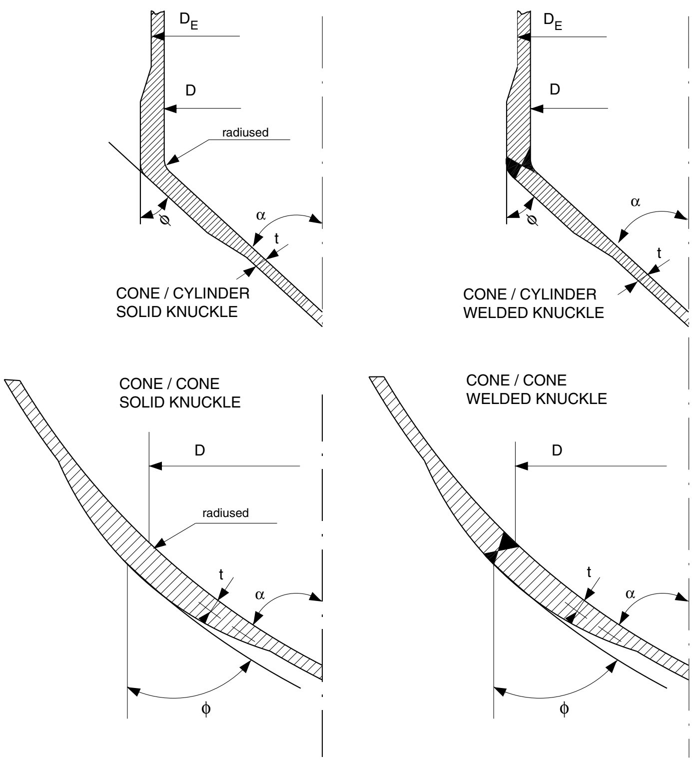
3.3.6 Minimum thickness

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.

Figure 2 : Conic shells



3.3.7 Corrosion allowance

Tasneef reserves the right to increase the corrosion allowance value in the case of vessels exposed to particular accelerating corrosion conditions. Tasneef 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 Tasneef 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

   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 Tasneef on a case-by-case basis.

3.3.11 Covers

a) Circular, oval and elliptical inspection openings are to be provided with steel covers. Inspection openings with a diameter not exceeding 150 mm 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 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].

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.

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

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

Figure 3 : Opening compensation

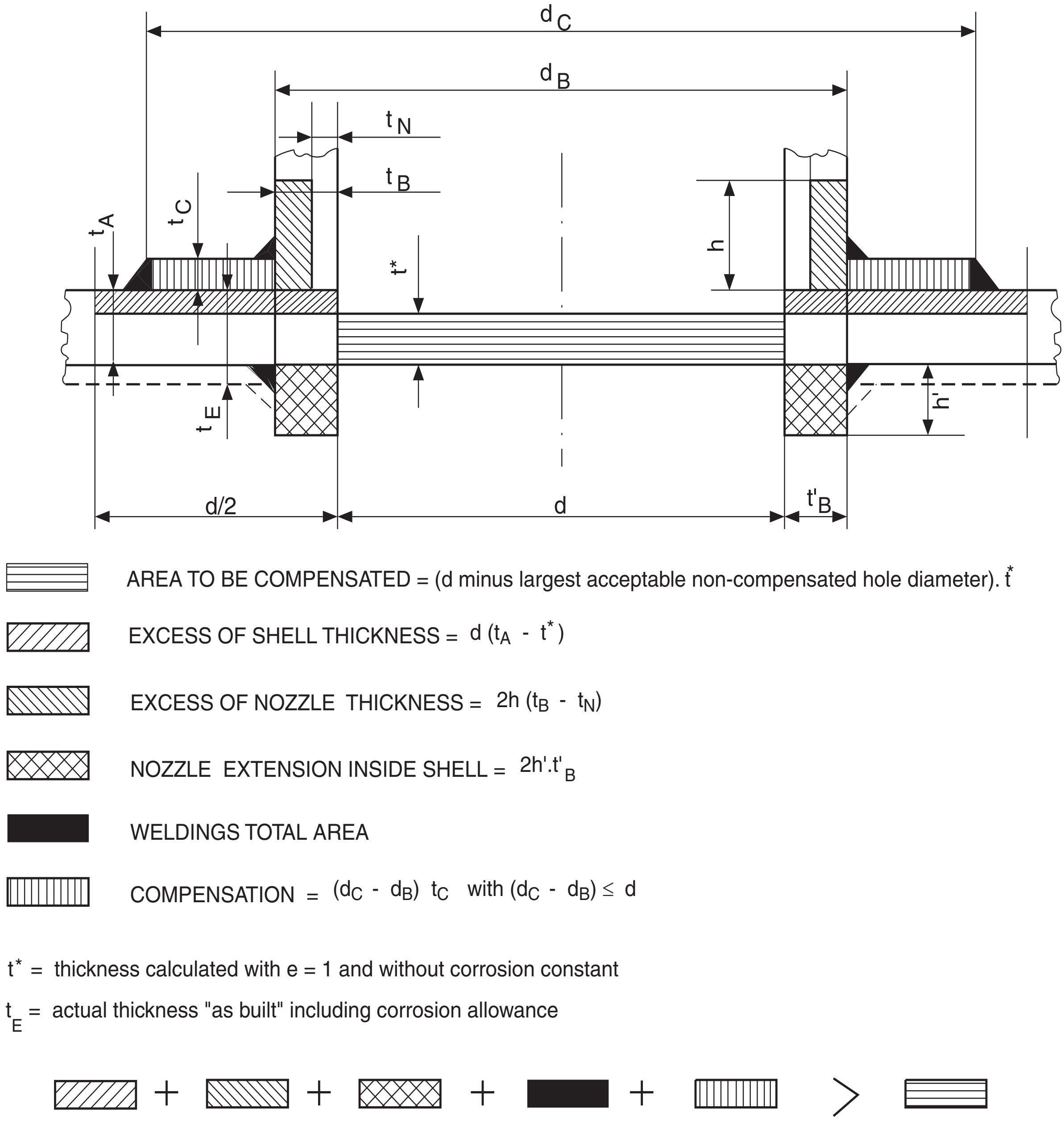
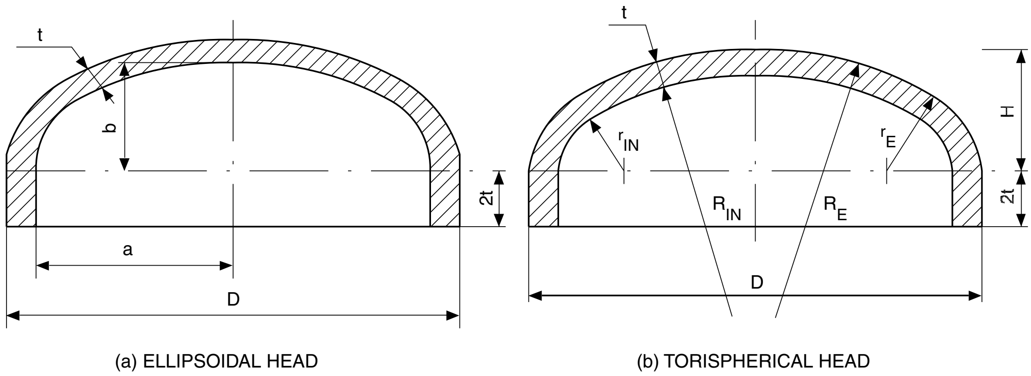


Table 6 : Coefficient C

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

Figure 4 : Dished head profiles



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 [3.4.2], 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 [3.4.1] and [3.4.2] the thickness t of dished heads is not to be less than:

- $3 + D_E/1500$ 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 to special consideration by Tasneef

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 [3.4.2] 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.

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.

Figure 5 : Shape factor for dished heads

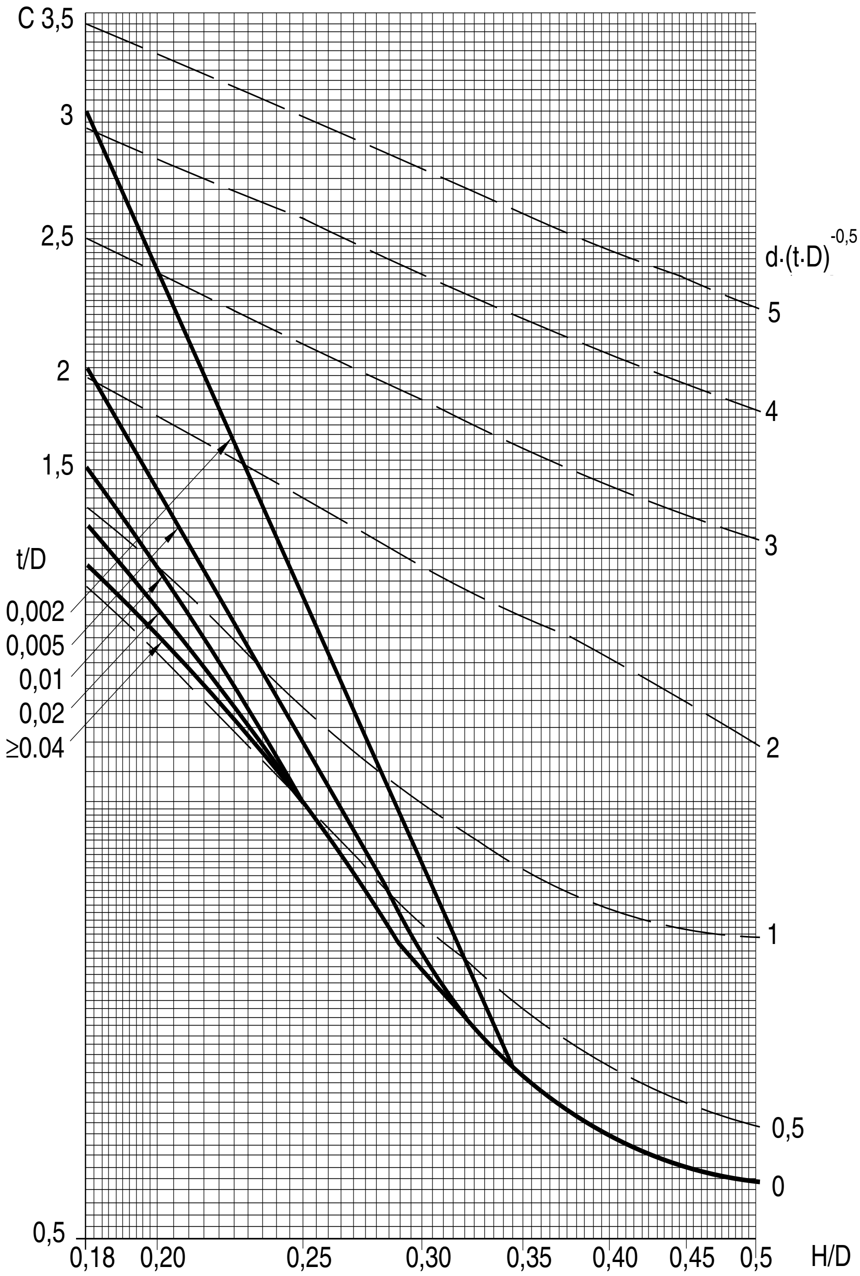
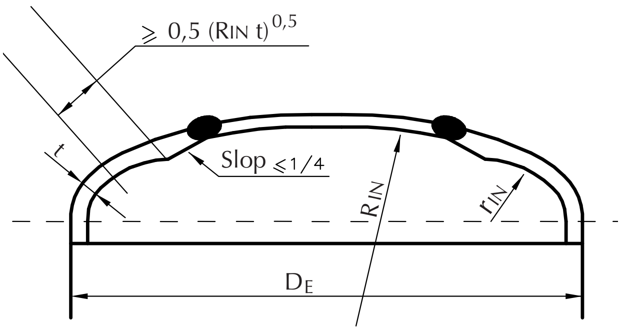


Figure 6 : Composed torispherical head



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 [3.4.2], 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 [3.4.2] 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 mm², of the total transverse section of the compensating parts

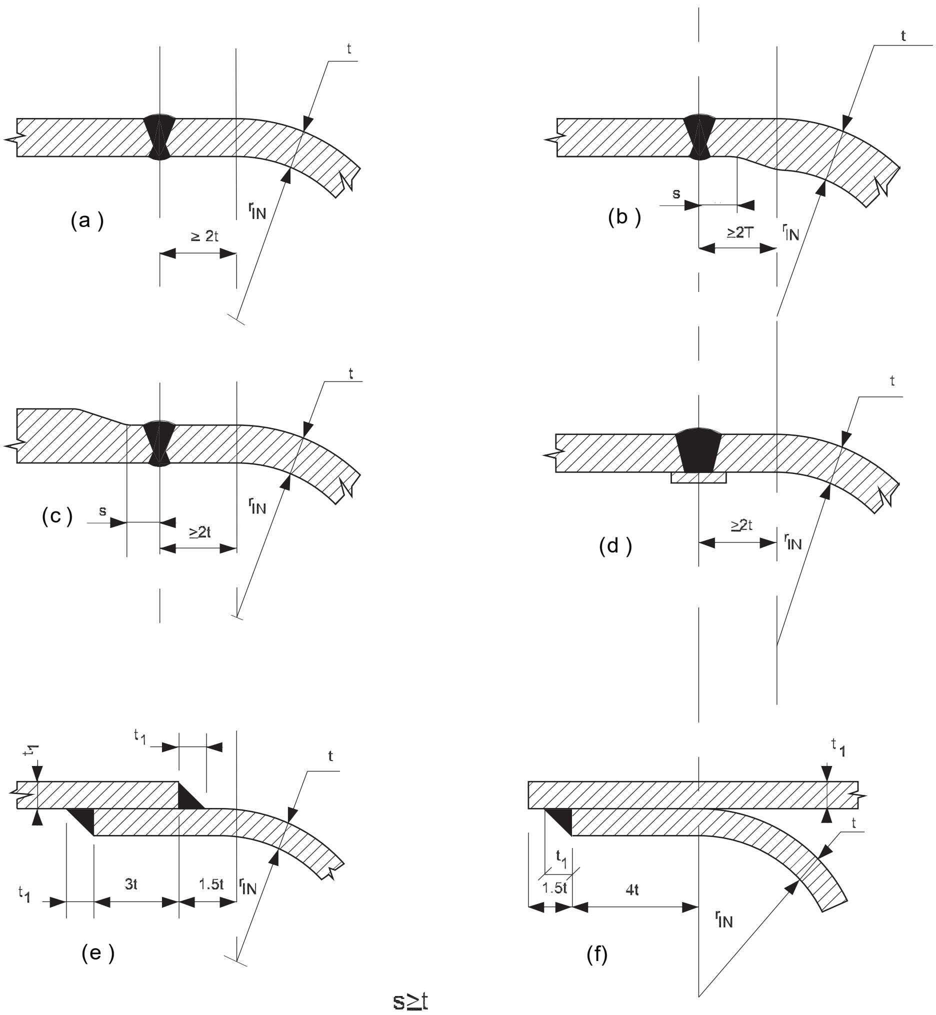
t : Actual thickness of the head, in mm, in the zone of the opening under consideration.

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.

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.

Figure 8 : Connection of hemispherical head to the cylindrical shell

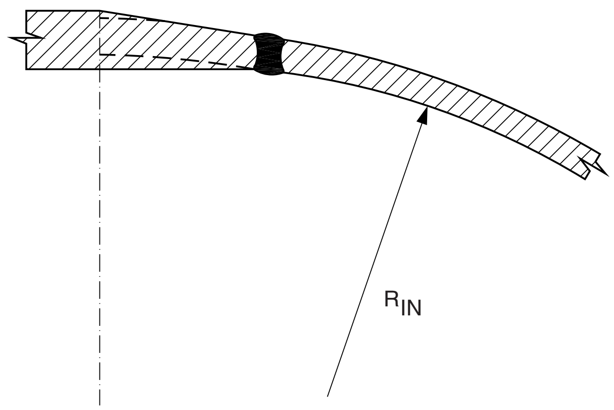
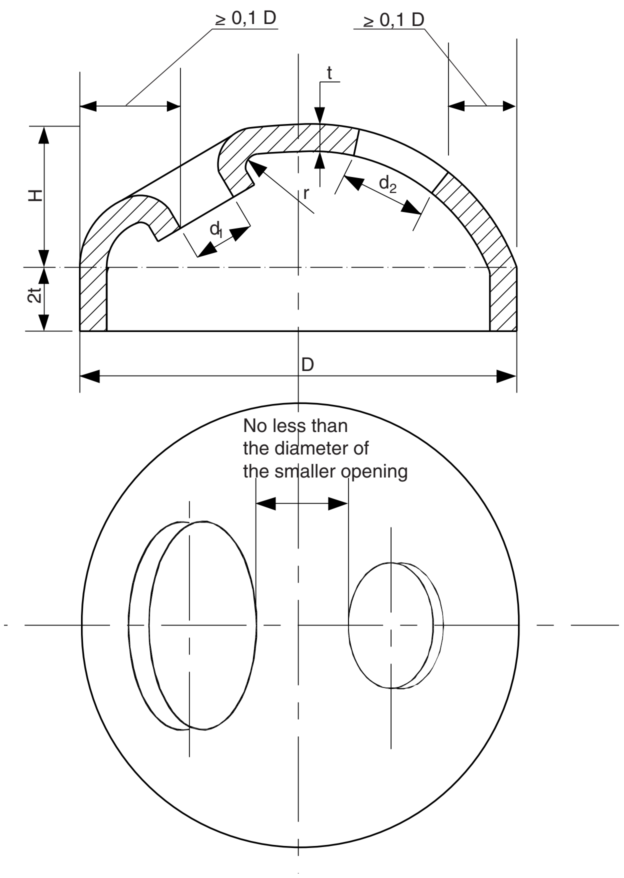


Figure 9 : Openings on dished heads



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.

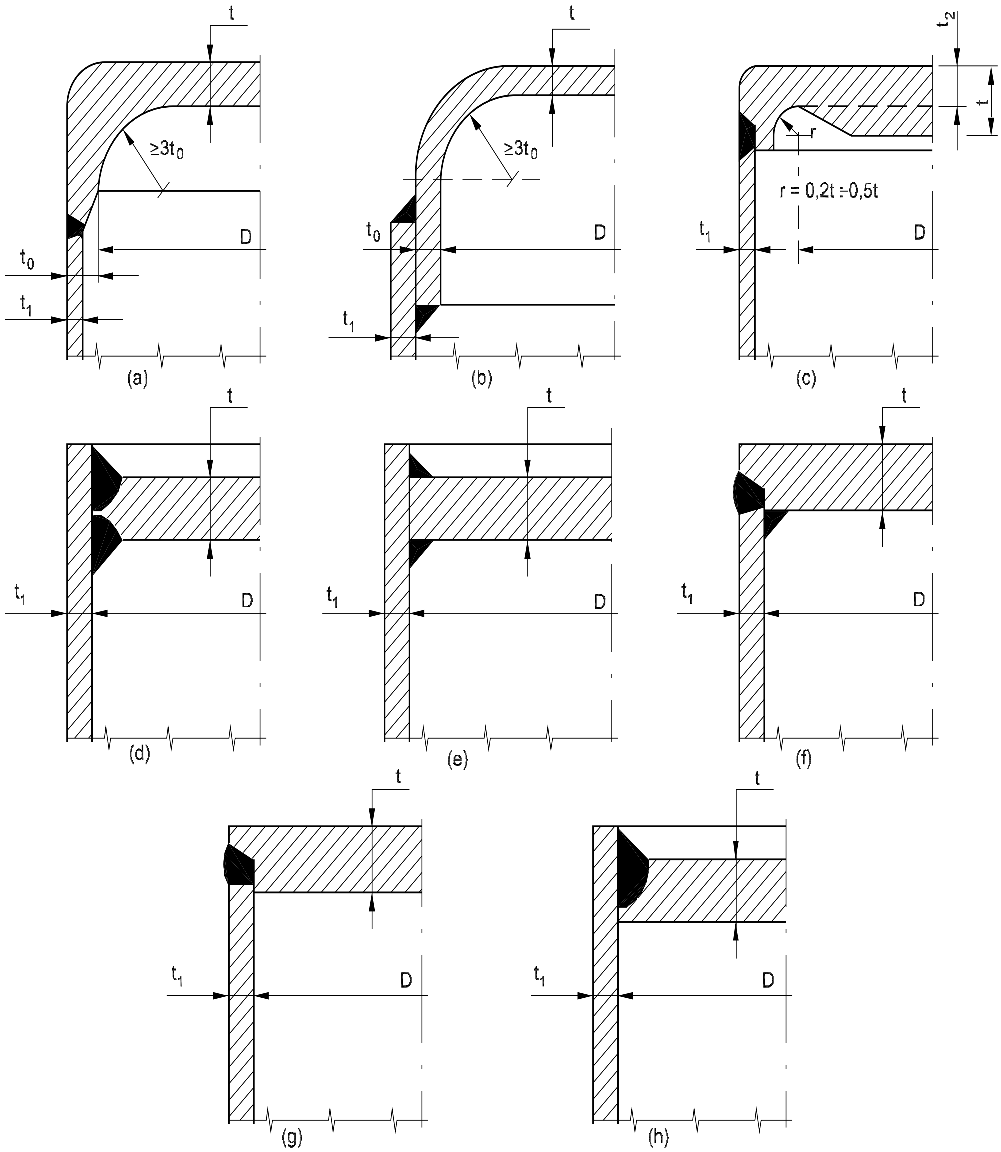
The adoption of one of the above-mentioned heads is subject to Tasneef approval depending upon its use. Types of heads not shown in Fig 10 and Fig 11 will be the subject of special consideration by Tasneef

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].

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:		
- 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

Figure 10 : Types of unstayed flat heads (1)



3.5.2 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.

3.6 Nozzles

3.6.1 Thickness

a) The thickness of the nozzle attached to shells and headers of 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 Tasneef 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 [2.8.1]).

c) For bottles exceeding the above capacity and dimensions, the following requirements may be applied at the discretion of Tasneef

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.

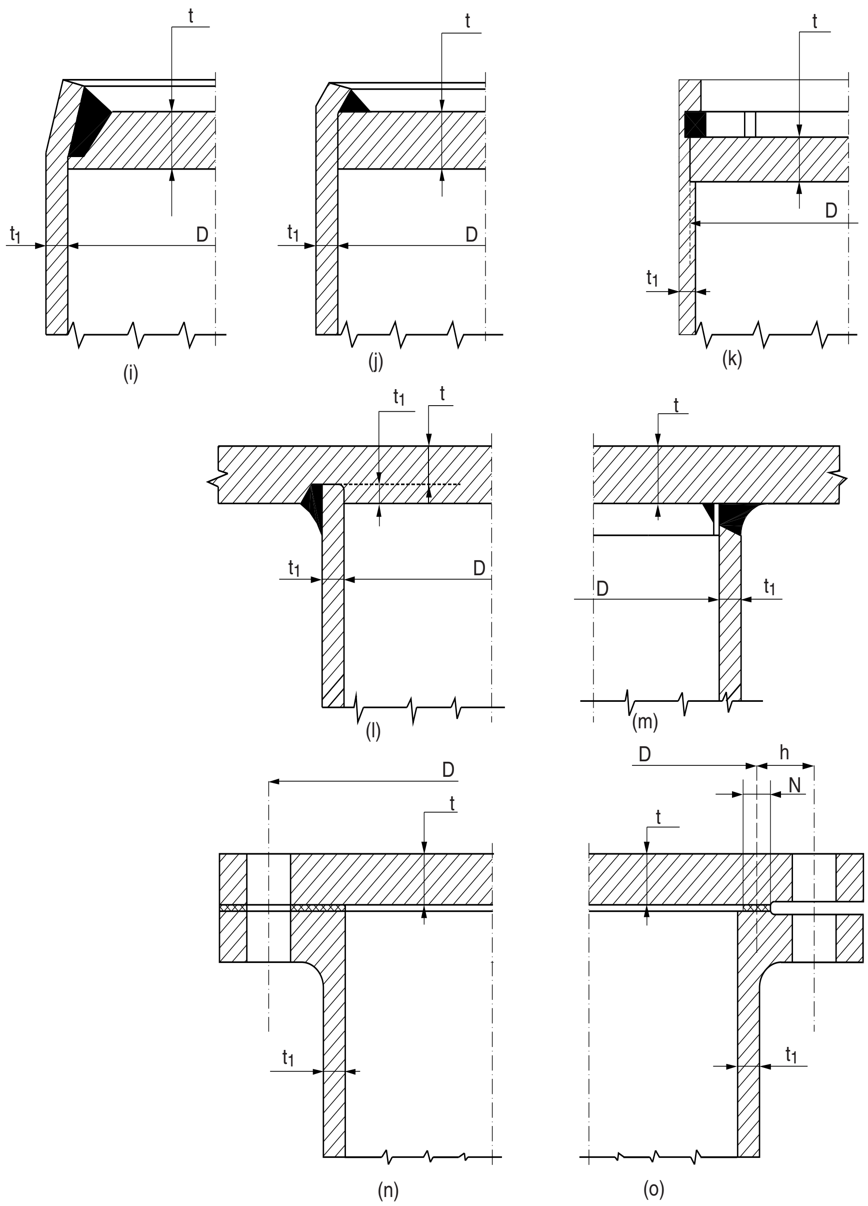
D_E : Outside diameter of tube, in mm

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/mm². 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.

Figure 11 : Types of unstayed flat heads (2)



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 Tasneef

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) Tube plates are to be designed in accordance with a recognised standard accepted by Tasneef

4 Design and construction - Fabrication and welding

4.1 General

4.1.1 Base materials

a) These requirements apply to 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

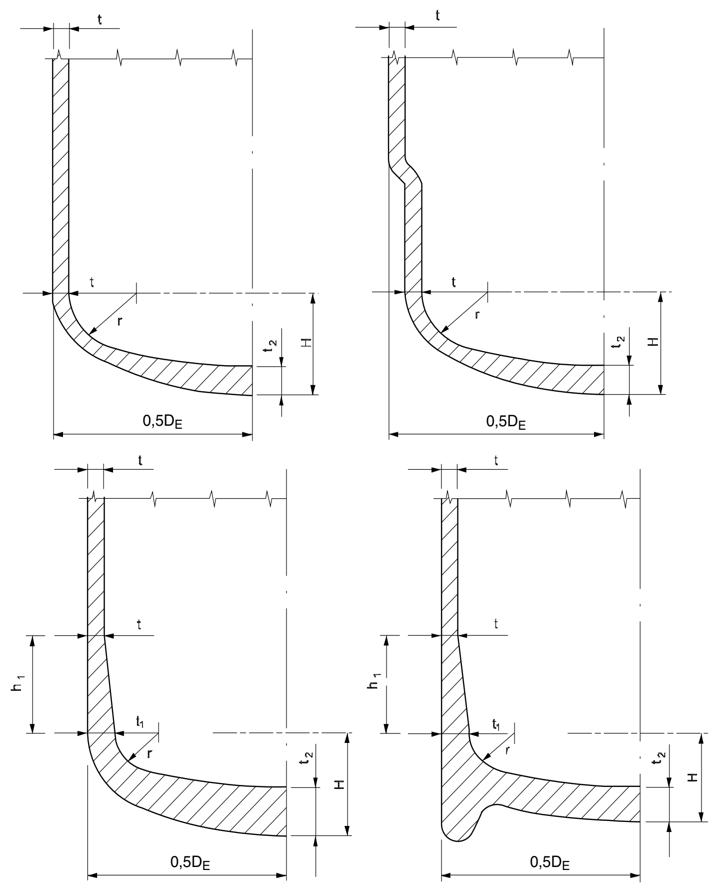
a) Welding is to be performed in accordance with welding procedures approved by Tasneef

b) Manual and semi-automatic welding is to be performed by welders qualified by Tasneef

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.

Figure 12 : Dished convex ends



$H/D_E \geq 0,20$ $r \geq 0,0075\ D_E$ $t_1 \geq 1,25\ t$ $t_2 \geq 1,5\ t$ $h_1 \geq 6\ t$

Figure 13 : Dished concave ends

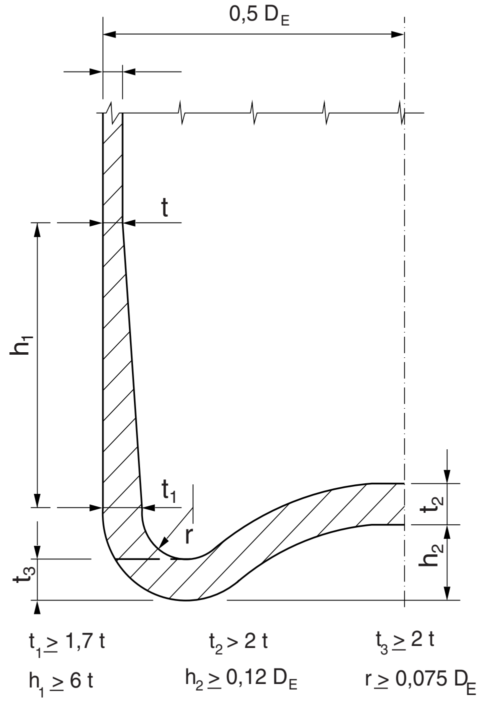
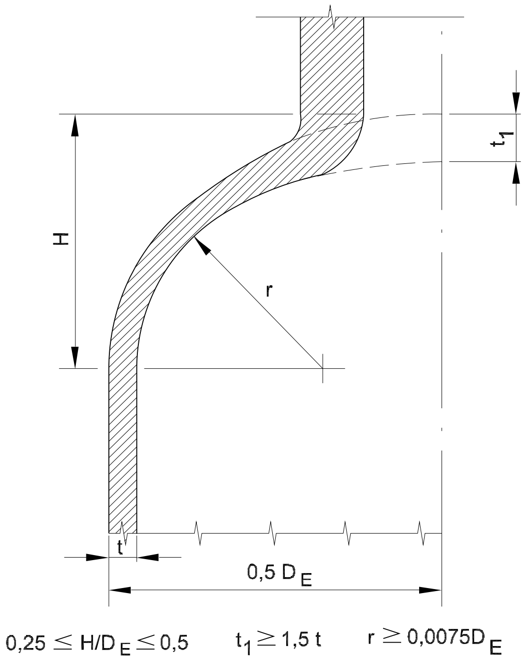


Figure 14 : Heads with openings



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. Tasneef 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 X-ray 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/mm² and 410 N/mm²
  - 15 mm for steels having R_m between 460N/mm² and 510N/mm² 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/mm², 510 N/mm², 0,3Mo, 1Mn 0,5Mo, 1Mn 0,5MoV and 0,5Cr 0,5Mo.

- After forming, the joints are to be subjected to X-ray examination or equivalent and to a magnetic particle or liquid penetrant test.

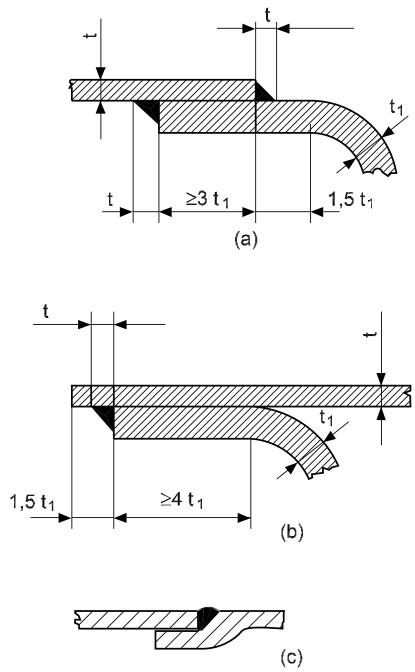
4.2 Welding design

4.2.1 Main welded joints

a) All joints of class 1 and 2 pressure parts of 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.

Figure 15 : Example of acceptable lap-joints



Details (b) and (c) may be used only for pressure vessels having internal diameter less than 600 mm.

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.

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 or 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 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 Type of welding

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 welding of typical pressure vessel connections. Any alternative type of welding or size will be the subject of special consideration by Tasneef

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 this into account.

4.3.2 Cleaning of parts to be welded

a) Parts to be welded are to be carefully cleaned for a distance of at least 25 mm from the welding edges 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.

Figure 16 : Types of joints for unstayed flat heads (1)

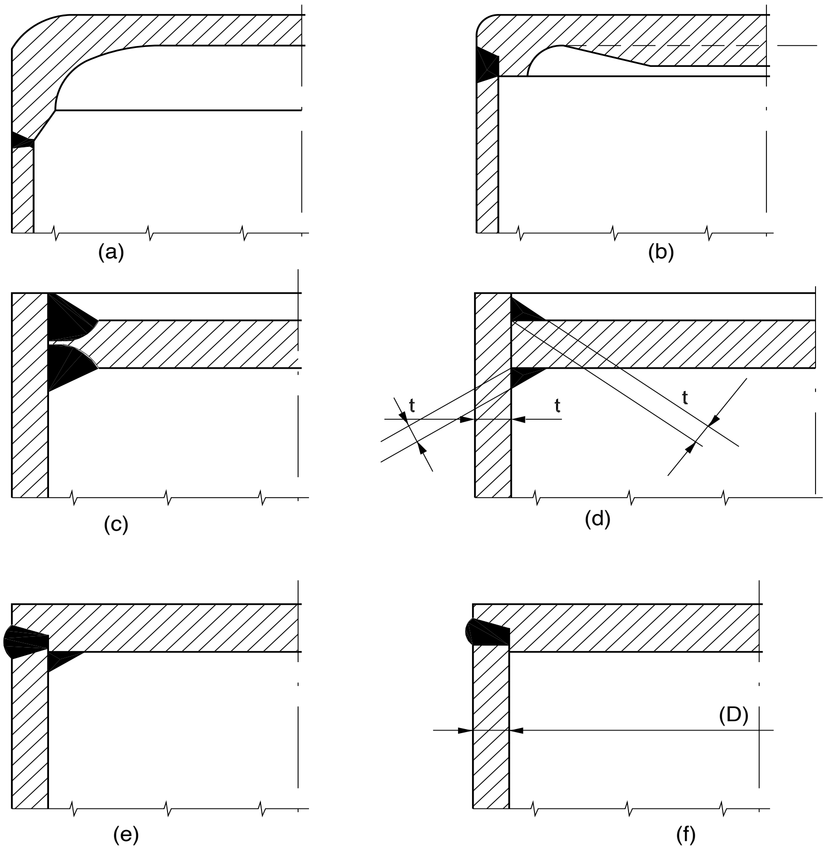


Figure 17 : Types of joint for unstayed flat heads (2)

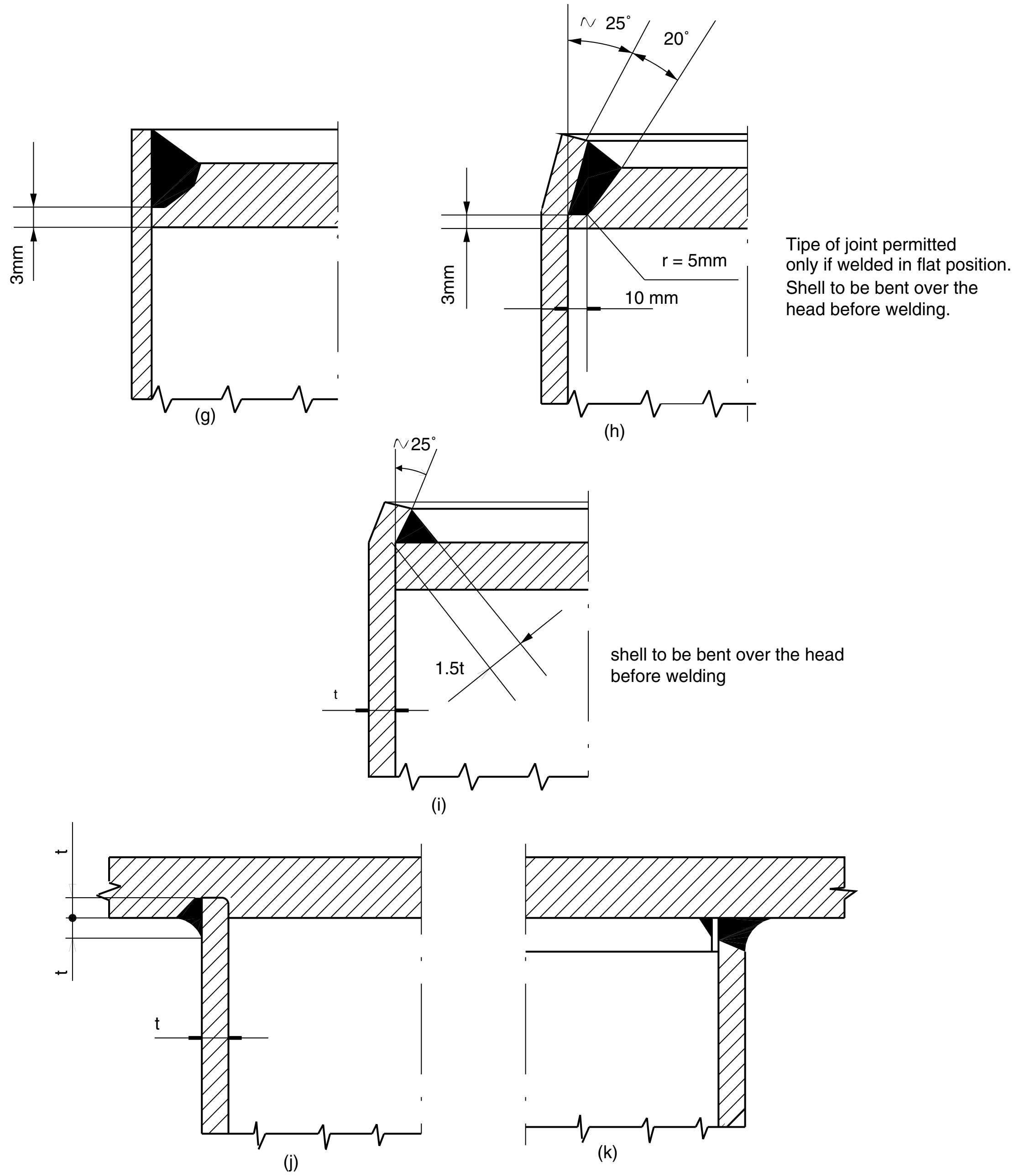


Figure 18 : Types of joints for nozzles and reinforcing rings (1)

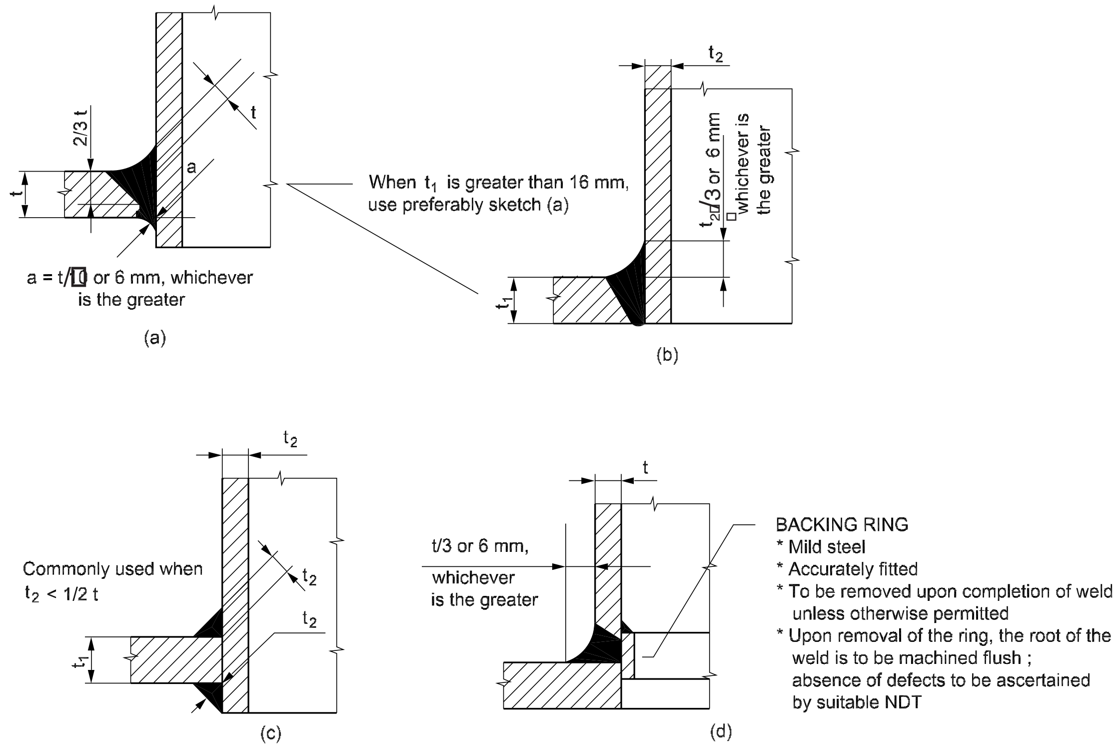


Figure 19 : Types of joint for nozzles and reinforcing rings (2)

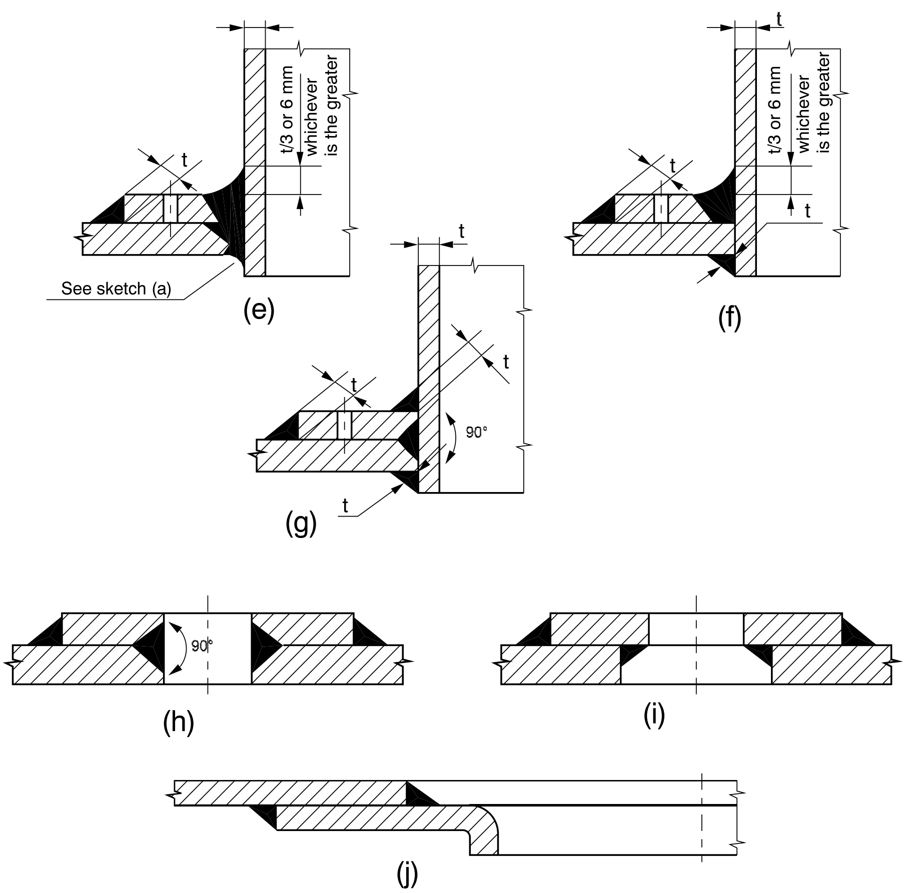


Figure 20 : Types of joint for nozzles and reinforcing rings (3)

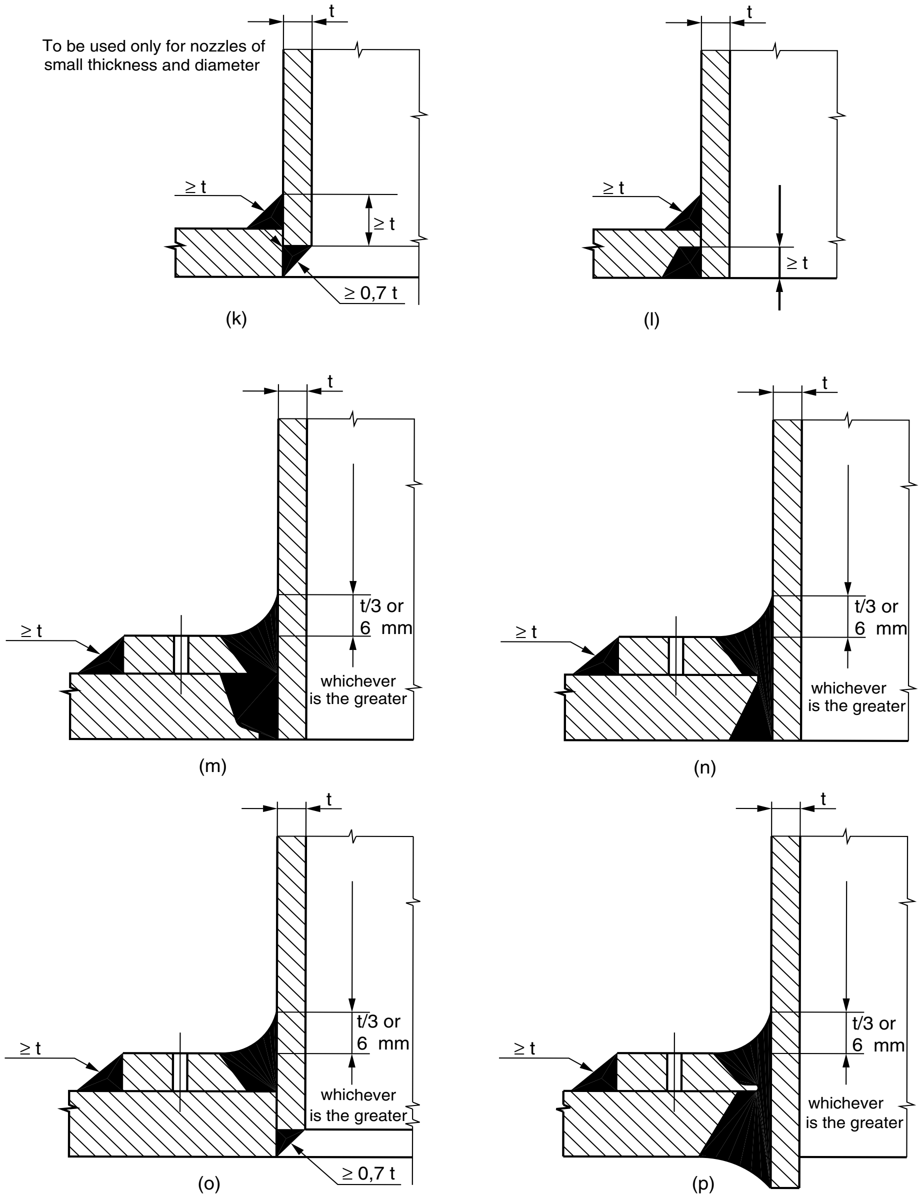
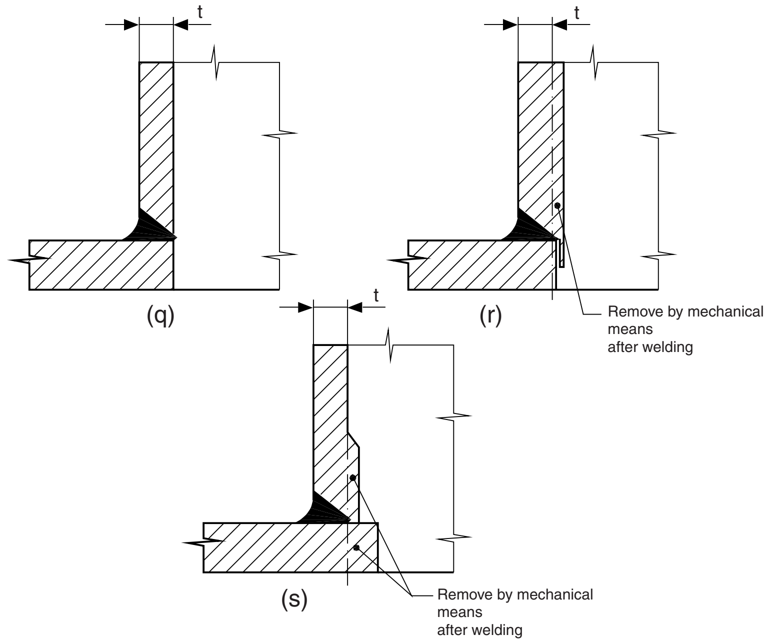


Figure 21 : Types of joints for nozzles (4)



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

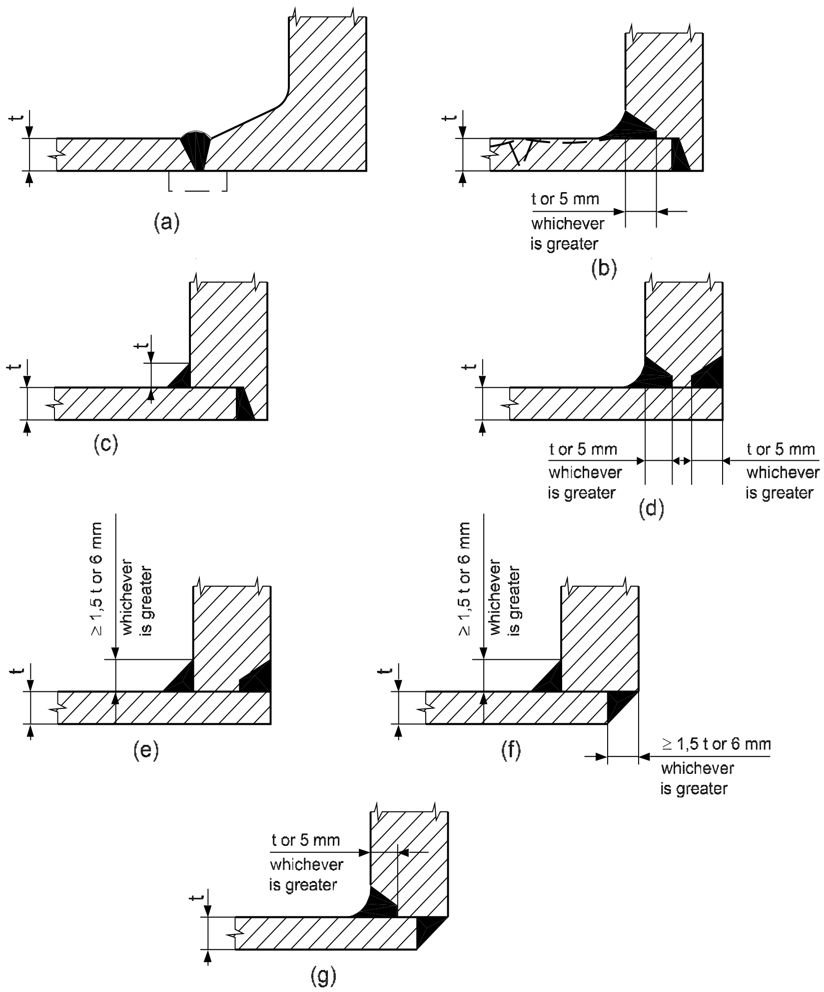


Figure 23 : Types of joint for tubesheets to shells (direct connection)

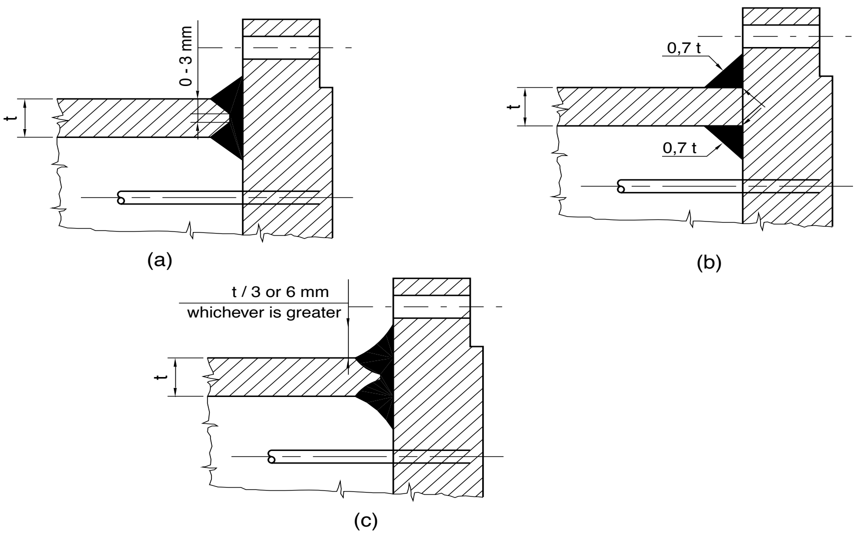
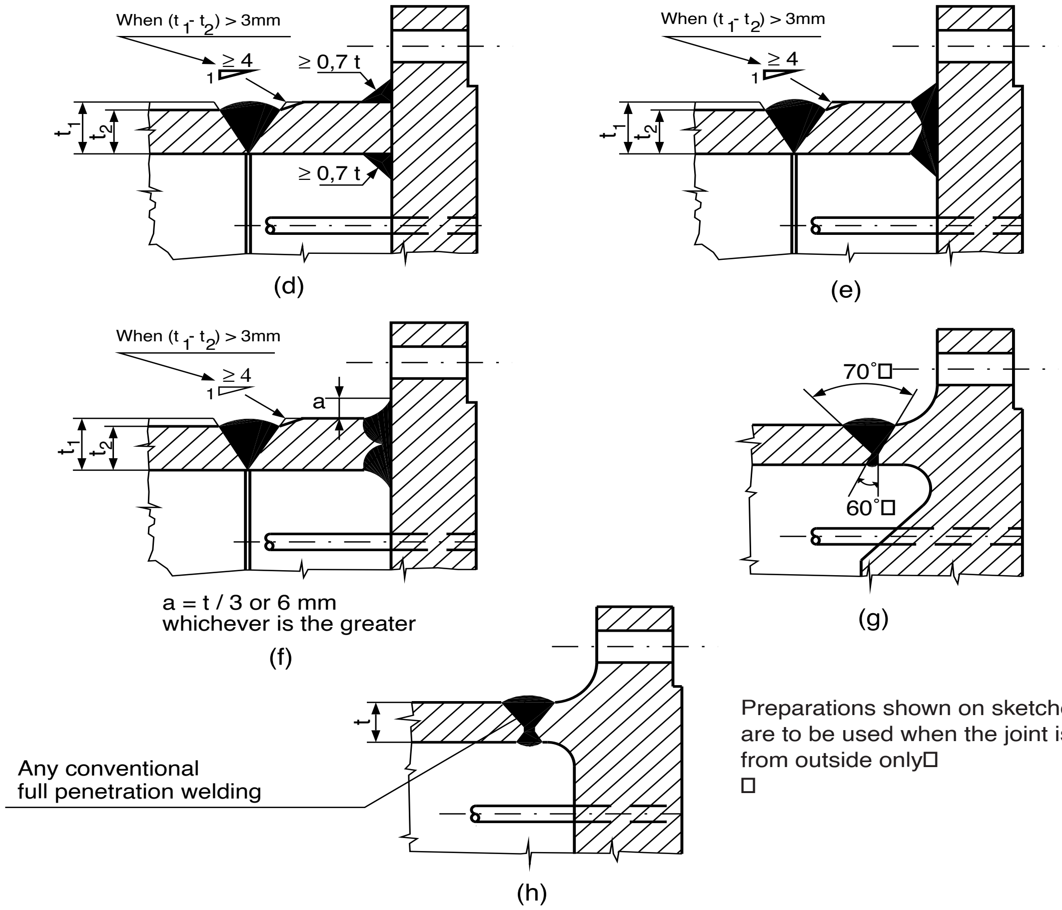
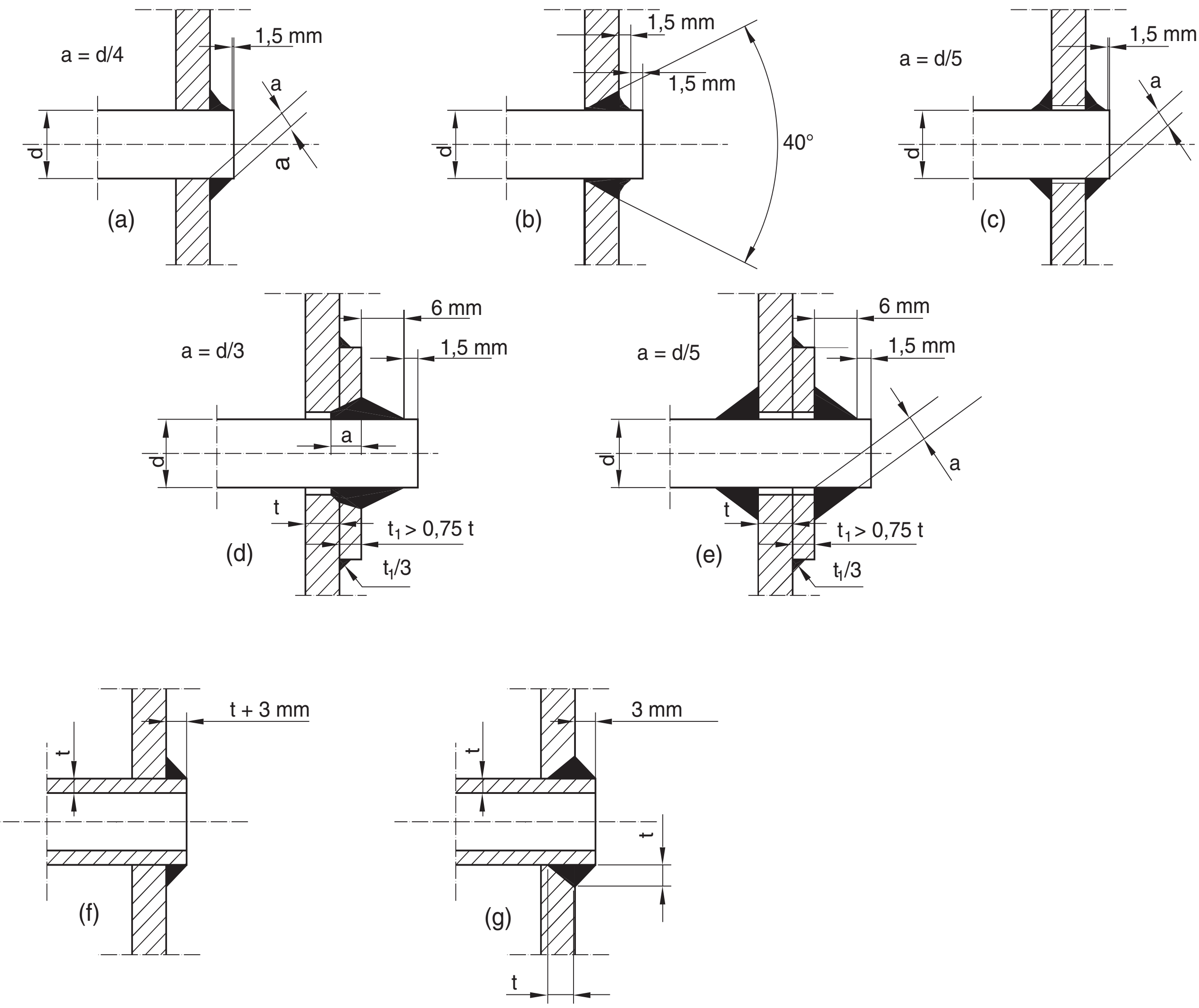


Figure 24 : Types of joints for tubesheets to shells (butt welded)



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



4.3.3 Protection against adverse weather conditions

a) Welding of pressure vessels is to be carried out 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 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 underthickness; 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:

- 2,5 mm for plates having a thickness not exceeding 12 mm
- 3 mm for plates having a thickness greater than 12 mm but less than 25 mm
- 5 mm for plates having a thickness at least equal to 25 mm.

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.

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. Tasneef 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 Tasneef 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, 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 Tasneef

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.

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

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 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 Tasneef 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 Tasneef

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 joints 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 to 100% radiographic or equivalent examination with the following exceptions:

- for pressure vessels or parts designed to withstand external pressures only, at Tasneef 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 material, made of carbon steels having thickness below 20 mm when the joints are welded by approved automatic processes at Tasneef 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 Tasneef 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 a magnetic particle test cannot be used, it is to be replaced by a 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 welding 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 for each 20 m of length of longitudinal joints (or fraction) and for 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 Tasneef discretion based on the actual thickness of the welded plates.

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 welding (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 requirements

5.2.1 Tab 10 summarises the control and monitoring requirements for incinerators.

6 Arrangement and installation

6.1 Foundations

6.1.1 For 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.

7 Material test, workshop inspection and testing, certification

7.1 Material testing

7.1.1 General

Materials, including welding consumables, for the constructions of 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 Tasneef discretion for mass produced small pressure vessels (such as accumulators for valve controls, gas bottles, etc.).

7.2 Hydrostatic tests

7.2.1 General

Hydrostatic tests of all class 1 and 2 pressure vessels are to be witnessed by the Surveyor.

For Manufacturers admitted to the alternative inspection, the tests are to be carried out as specified in the agreed scheme.

For class 3 pressure vessels, shop certificates may be accepted.

7.2.2 Testing pressure

a) Upon completion, pressure parts of 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 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.

7.2.3 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.

7.2.4 Hydraulic test procedure

a) The hydraulic test specified in [7.2.1] 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.

7.3 Fibre reinforced plastic pressure vessels

7.3.1 General

a) Pressure vessels may be constructed in fibre reinforced plastics provided the Manufacturer is competent and suitably equipped for this purpose.

b) Pressure vessels are to be of standard design whose suitably has been established by fatigue and burst tests on a prototype.

7.3.2 Testing

a) For the fatigue test the pressure is to be cycled from atmospheric to design pressure 100.000 times at the design temperature.

b) For the burst test the minimum bursting pressure is to be six times the design pressure.

7.3.3 Production hydraulic test

Vessels subject to internal pressure are to be hydraulically tested to not less than 1,5 times the design pressure.

7.4 Certification

7.4.1 Certification of class 1 and 2 pressure vessels

For Manufacturers admitted to the alternative inspection, the requested certificates are specified in the agreed scheme.

7.4.2 Pressure vessels not required to be certified

The Manufacturer’s certificate, including detail of tests and inspection, is to be submitted to Tasneef for pressure vessels not required to be certified by Tasneef 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.

8 Type approved pressure vessels

8.1 Issue and renewal of Tasneef Type Approval Certificate

8.1.1 Issue of Tasneef Type Approval Certificate *(1/1/2019)*

For yachts less than 500 GT, when ✠ **MACH class notation** is to be assigned, the pressure vessels to which this Section is applicable according to [1.1.1] as an alternative may be type approved by Tasneef

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 Tasneef 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.

8.1.2 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 Tasneef

SECTION 4 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, having P ≥ 110 kW

when intended for yachts to be assigned the ✠ **MACH** notation.

1.1.2 Gas turbines intended for yachts to be assigned the ● **MACH** notation and all other gas turbines are to be designed and constructed according to sound marine practice and delivered with the relevant works' certificates (see Pt D, Ch 1, Sec 1, [4.2.3]).

1.2 Definition of rated power

1.2.1 Rated power is the maximum power as declared by the Manufacturer according to a recognised standard.

1.3 Documentation to be submitted

1.3.1 For propulsion turbines and turbines intended for driving machinery for essential services, having P ≥ 110 kW, 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 Tasneef 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 Vibration analyses

2.2.1 The range of service speeds is not to give rise to unacceptable bending vibrations or to vibrations affecting the entire installation.

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.

Table 1 : Documents to be submitted

No	A/I **(1)**	ITEM
1	I	Sectional assembly
2	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
3	I	Diagrammatic layout of the fuel system, including control and safety devices, and of the lubricating oil system
4	I	Maintenance and overhaul procedures
(1) A = to be submitted for approval in four copies I = to be submitted for information in triplicate		

2.3.2 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.

2.3.3 Turning gear

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

2.3.4 Cooling

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

2.3.5 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.

2.3.6 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, to limit the airborne noise.

2.3.7 Multi-turbine installations

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

2.3.8 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 2, [3.1.1].

2.3.9 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.

2.3.10 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.

2.4 Control, monitoring and shut-off devices

2.4.1 Control and monitoring arrangement

For each main propulsion system, the associated control and monitoring equipment is to be grouped together at each location from which the turbine may be controlled.

2.4.2 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 the maximum declared by the Manufacturers.

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 speed from exceeding the maximum declared by the Manufacturer.

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 Tasneef on a case-by-case basis based on the actual turbine design and arrangement.

2.4.3 Monitoring system

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

2.4.4 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.

2.4.5 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

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.

2.4.6 Indicators, alarm and shutdown

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

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.

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	Slowdown	Shutdown	Control	Standby 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					
• Number of cycles of rotating part performed	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			
• Pressure at compressor inlet (alarm before shutdown)		local					
	L			X			
Lubricating oil							
• Turbine supply pressure		local					
	L			X			
• Differential pressure across lubricating oil filter	H	local					
• Bearing or lubricating oil (discharge) temperature	H	local					

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, [2.4].

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) 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 Instruments

3.6.1 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 Material tests

4.1.1 The materials for the construction of the parts listed in Tab 3 are to be tested in compliance with the requirements of Part D of the Rules to be qualified for assignment of the ✠ **MACH notation.**

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.

4.2 Inspections and testing during construction

4.2.1 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 intended for yachts having the ✠ **MACH notation**. For on-board trials see Sec 14, [3.6].

- Material tests as required (see [4.1]).
- Welding fabrication (see [4.2.2]).
- Hydrostatic tests (see [4.2.3]).
- Rotor balancing and overspeed test (see [4.2.4], [4.2.5]).
- Shop trials (see [4.2.6] and [4.2.7]).

4.2.2 Welding fabrication

Welding fabrication and testing are to be attended by the Surveyor, as may be deemed necessary by Tasneef

4.2.3 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 Tasneef Where the hydrostatic test cannot be performed, alternative methods for verifying the integrity of the casings may be agreed between the Manufacturer and Tasneef on a case-by-case basis.

4.2.4 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.

4.2.5 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 operating speed.

Tasneef 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.

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 X-Ray 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

4.2.6 Main propulsion engines driving propellers

Main propulsion engines are to be subjected to trials to be performed as follows:

a) at least 60 min, after having reached steady conditions, at rated power P and rated speed n

b) 30 min, after having reached steady conditions, at 110% of rated power P and at a speed equal to 1,032 of rated speed

c) tests at 90% (or normal continuous cruise power), 75%, 50% and 25% of rated power P, carried out:
- at the speed corresponding to the nominal (theoretical) propeller curve, for engines driving fixed pitch propellers
- at constant speed, for engines driving controllable pitch propellers

d) idle run

e) starting tests

f) testing of the speed governor and of the independent overspeed protective device

g) testing of alarm and/or shutdown devices.

Note 1: After running on the test bed, the fuel delivery system is to be so adjusted that the engine cannot deliver more than 100% of the rated power at the corresponding speed (overload power cannot be obtained in service).

4.2.7 Engines driving electric generators used for main propulsion purposes

Engines driving electric generators are to be subjected to trials to be performed with a constant governor setting, as follows:

a) at least 60 min, after having reached steady conditions, at 100% of rated power P and rated speed n

b) 45 min, after having reached steady conditions, at 110% of rated power and rated speed

c) 75%, 50% and 25% of rated power P, carried out at constant rated speed n

d) idle run

e) starting tests

f) testing of the speed governor (Sec 2, [2.4.5]) and of the independent overspeed protective device (when applicable)

g) testing of alarm and/or shutdown devices.

Note 1: After running on the test bed, the fuel delivery system of diesel engines driving electric generators is to be adjusted such that overload (110%) power can be produced but not exceeded in service after installation on board, so that the governing characteristics, including the activation of generator protective devices, can be maintained at all times.

4.3 Certification

4.3.1 Testing certification

a) Turbines as per [1.1.1] admitted to an alternative inspection scheme

Works' certificates (W) (see Pt D, Ch 1, Sec 1, [4.2.3]) are required for components and tests indicated in Tab 3 and tests and trials listed in [4.2.1]. However, Tasneef reserves the right to request that the shop trials are witnessed by a Surveyor on a case-by-case basis.

b) Turbines as per [1.1.1] not admitted to an alternative inspection scheme

Tasneef certificates (C) (see Pt D, Ch 1, Sec 1, [4.2.1]) are required for material tests of rotating components and blades listed in Tab 3 and for works trials as per [4.2.3], [4.2.4], [4.2.6] and [4.2.7].

Works' certificates (W) (see Pt D, Ch 1, Sec 1, [4.2.3]) are required for the other items listed in Tab 3 and for trials described in [4.2.2] and [4.2.5].

4.4 Type approved gas turbines

4.4.1 Issue of Tasneef Type Approval Certificate *(1/1/2019)*

For yachts less than 500 GT, when ✠ **MACH** class notation is to be assigned, the gas turbines defined in [1.1.1] a) and b) as alternative may be type approved by Tasneef

For a particular type of gas turbine, 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 [4].

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 gas turbines 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.

4.4.2 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 Tasneef

SECTION 5 GEARING

1 General

1.1 Application

1.1.1 *(1/1/2016)*

Unless otherwise specified, for yachts equal or more of 500 GT in any case, for yachts of less than 500 GT only when Maltese cross is required, 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.

Some deviations from the requirements of this Section may be accepted by the Society in cases of gears fitted to yachts having a restricted 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.

1.2 Documentation to be submitted

1.2.1 Documents *(1/1/2016)*

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 *(1/1/2016)*

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 1997
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
7	A	Functional diagram of control, monitoring and safety systems

(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

No.	I/A (1)	Document (2)
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 *(1/1/2016)*

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 *(1/1/2016)*

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)

2 Design of gears - Determination of the load capacity

2.1 Symbols, units, definitions

2.1.1 Symbols and units *(1/1/2016)*

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

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 1997

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 mm

$R_{z(r)}$: Mean root peak-to-valley roughness, in mm

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 speed 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 *(1/1/2016)*

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})

$$Z_{n1,2\alpha} = \frac{Z_{1,2}}{\cos^2\beta_b \cos\beta}$$

$$m_t = \frac{m_n}{\cos\beta}$$

$$\mathrm{inv}\alpha = \tan\alpha - \frac{\Pi\alpha}{180};[^o]$$

$$\mathrm{inv}\alpha_{tw} = \mathrm{inv}\alpha_t + 2\tan\alpha_n \frac{x_1 + x_2}{z_1 + z_2}$$

$$\cos\alpha_{tw} = \frac{m_1(z_1 + z_2)}{2a}\cos\alpha_t$$

for external gears:

$$\varepsilon_\alpha = \frac{0,5 \cdot (d_{a1}^2 - d_{b1}^2)^{\frac{1}{2}} + 0,5 \cdot (d_{a2}^2 - d_{b2}^2)^{\frac{1}{2}} - (a \cdot \sin\alpha_{tw})}{\pi \cdot m_n \cdot \cos\alpha_t}$$

for internal gears:

$$\varepsilon_\alpha = \frac{0,5 \cdot (d_{a1}^2 - d_{b1}^2)^{\frac{1}{2}} - 0,5 \cdot (d_{a2}^2 + d_{b2}^2)^{\frac{1}{2}} - (a \cdot \sin\alpha_{tw})}{\pi \cdot m_n \cdot \cos\alpha_t}$$

$$\varepsilon_\beta = \frac{b \cdot \sin\beta}{\pi \cdot m_n}$$

$$\varepsilon_\gamma = \varepsilon_\alpha + \varepsilon_\beta$$

$$v = \pi d_{1,2} n_{1,2} / 60 \cdot 10^3$$

2.2 Principle

2.2.1 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

The load sharing factor K_γ accounts for the uneven sharing of load on multiple path transmissions, such as epicyclic gears or tandem gears.

The values of K_γ are given in Tab 4.

Table 4 : Values of K_g *(1/1/2016)*

Type of gear		K_g
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 to improve the load distribution between the gears.		

2.3.4 Dynamic factor K_V *(1/1/2016)*

The 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:

$$\frac{v \cdot Z_1}{100}\sqrt{\frac{u^2}{1+u^2}} < 10\,m/s$$

- spur gears ($b = 0°$) and helical gears with $b \le 30°$
- pinion with relatively low number of teeth, $z_1 < 50$
- solid disc wheels or heavy steel gear rim

and also when

$$\frac{v \cdot Z_1}{100}\sqrt{\frac{u^2}{1+u^2}} < 3\,m/s$$

in this case it is also applicable to gears having $b > 30°$.

Table 5 : Values of K_V *(1/1/2016)*

Type of gear	K_V		Limitations
Spur gear	$K_{V2} = 1 + \left(\frac{K_1}{K_A\frac{F_t}{b}} + K_2\right) \cdot \frac{v \cdot Z_1}{100} K_3 \sqrt{\frac{u^2}{1+u^2}}$ where K_1 has the values specified in Tab 5		$K_2 = 0,0193$
Helical gear	• if $\varepsilon_\beta \ge 1$:	$K_{V2} = 1 + \left(\frac{K_1}{K_A\frac{F_t}{b}} + K_2\right) \cdot \frac{v \cdot z_1}{100} K_3 \sqrt{\frac{u^2}{1+u^2}}$ where K_1 has the values specified in Tab 5	$K_2 = 0,0087$
	• if $\varepsilon_\beta < 1$:	$K_V = K_{V\alpha} - \varepsilon_\beta \cdot (K_{V\alpha} - K_{V\beta})$ where $K_{V\alpha}$ is calculated as if the gear were of spur type	

Table 6 : Values of K_1 *(1/1/2016)*

	ISO grade of accuracy Error! Reference source not found.					
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. 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 method B.

Factor K_3 is to be in accordance with the following:

- if

$$\frac{v \cdot z_1}{100}\sqrt{\frac{u^2}{1+u^2}} \le 0,2$$

then K_3 = 2,0

- if

$$\frac{v \cdot z_1}{100}\sqrt{\frac{u^2}{1+u^2}} > 0,2$$

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_{Hb} and K_{Fb} *(1/1/2016)*

a) The face load distribution factors, K_{Hb} for contact stress and K_{Fb} 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:

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 $K_{F\beta}$ is:

$$K_{F\beta} = K_{H\beta}^N$$

$$N = \frac{(b/h)^2}{1+(b/h)+(b/h)^2}$$

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 $K_{F\alpha}$ *(1/1/2016)*

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.

2.4 Calculation of surface durability

2.4.1 General *(1/1/2016)*

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 *(1/1/2016)*

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 factor for pinion (see [2.4.4]),

Z_D : Single pair tooth 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} *(1/1/2016)*

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 : Speed 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, or assumed to be 1,
- S_H : Safety factor for contact stress (see [2.4.12]).

2.4.4 Single pair mesh factors Z_B and Z_D *(1/1/2016)*

The single pair tooth 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 *(1/1/2016)*

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 force 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 *(1/1/2016)*

The elasticity factor Z_E accounts for the influence of the metal properties (module of elasticity E and Poisson's ratio n) 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 6336-1.

2.4.7 Contact ratio factor Z_ε *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

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.

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, mm²/s
- C_{ZL} :
  - for $\sigma_{H,lim} < 850\ N/mm^2$
    $C_{ZL} = 0{,}83$
  - for $850\ N/mm^2 \leq \sigma_{H,lim} \leq 1200\ N/mm^2$

$$C_{ZL} = 0,08\left(\frac{\sigma_{H,lim} - 850}{305}\right) + 0,83$$

  - for $\sigma_{H,lim} > 1200\ N/mm^2$
    $C_{ZL} = 0{,}91$

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 $\le \sigma_{H,lim} \le$ 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,

$$R_{Z(f)} = \frac{R_{Z(f)1} + R_{Z(f)2}}{2}$$

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 relationship may be applied:

$$R_a = CLA = AA = R_6 / 6$$

C_{ZR} : Coefficient having the following values:

- for $\sigma_{H,lim} < 850$ N/mm²
  $C_{ZR} = 0{,}15$
- for 850 N/mm² $\le \sigma_{H,lim} \le$ 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 *(1/1/2016)*

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

$$R_{ZH} = \frac{R_{Z1} \cdot (10/\rho_{red})^{0,33} \cdot (R_{Z1}/R_{Z2})^{0,66}}{(V \cdot \nu_{40}/1500)^{0,33}}$$

ρ_{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 $1{,}2 \le HB_1 / HB_2 \le 1{,}7$

$$Z_W = 1 + \left(0,00898 - \frac{HB_1}{HB_2} - (0,00829)\right) \cdot (u - 1)$$

- if $HB_1 / HB_2 > 1{,}2$

$$Z_W = 1 + 0,00698 \cdot (u - 1)$$

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 *(1/1/2016)*

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 σ_H *(1/1/2016)*

The values to be adopted for the safety factor for contact stress σ_H are given in Tab 7.

Table 7 : Safety factor for contact stress σ_H *(1/1/2016)*

Type of installation		σ_H
Main gears (propulsion)	single machinery	1,25
	duplicate machinery	1,20
Auxiliary gears		1,15

2.4.13 Endurance limit for contact stress $\sigma_{H,lim}$ *(1/1/2016)*

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, 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 $\sigma_{H,lim}$ *(1/1/2016)*

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 *(1/1/2016)*

The criterion for tooth bending strength is based on the 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.

2.5.2 Tooth root bending stress σ_F *(1/1/2016)*

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 [2.5.4])

Y_{DT} : Deep tooth factor (see [2.3.2])

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} *(1/1/2016)*

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 *(1/1/2016)*

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.

2.5.5 Stress correction factor Y_S *(1/1/2016)*

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 *(1/1/2016)*

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 $\varepsilon_\beta \leq 1$:

$$Y_\beta = \varepsilon_\beta - (b \cdot 120)$$

- for $\varepsilon_\beta > 1$:

$$Y_\beta = 1 - b$$

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 *(1/1/2016)*

The rim thickness factor Y_B is a simplified factor used to derate 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 $s_R/h > 1{,}2$

$$Y_B = 1$$

$$Y_B = 1,6 \cdot \ln\left(2,242\frac{h}{s_R}\right)$$

where:

s_R : Rim thickness of external gears, mm

h : Tooth heigth, 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 external gears, mm

The case $s_R/h \leq 1{,}75$ is to be avoided.

2.5.8 Deep tooth factor Y_{DT} *(1/1/2016)*

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 $2{,}05 \leq \varepsilon_{\alpha v} \leq 2{,}5$, where:

$$\varepsilon_{\alpha n} = \frac{\varepsilon_\alpha}{\cos^2\beta_b}$$

Factor Y_{DT} is to be determined as follows:

- if ISO accuracy grade $\leq$ 4 and $\varepsilon_{\alpha v} > 2{,}5$

$$Y_{DT} = 0,7$$

- if ISO accuracy grade $\leq$ 4 and $2{,}05 \leq \varepsilon_{\alpha v} \leq 2{,}5$

$$Y_{DT} = 2,366 - 0,666\varepsilon_n$$

- in all other cases

$$Y_{DT} = 1,0$$

2.5.9 Endurance limit for tooth root bending stress σ_{FE} *(1/1/2016)*

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, for material quality MQ or as given in Tab 9 in relation to the type of steel employed.

Figure 1 : Geometric elements of teeth *(1/1/2016)*

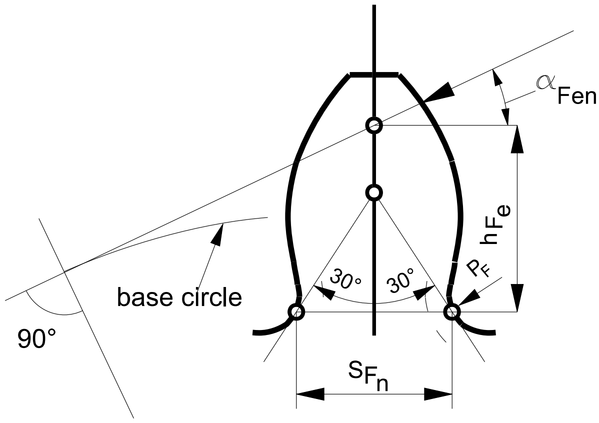


Table 9 : Values of endurance limit for tooth root bending stress σ_{FE} *(1/1/2016)*

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
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 the 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 *(1/1/2016)*

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:

  $$Y_{ds} = 1 - \frac{\sigma}{\sigma_{FEt}}$$

  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 *(1/1/2016)*

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 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 $Y_{\delta rel\ T}$ *(1/1/2016)*

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:

$$Y_{\delta relT} = \frac{1 + \sqrt{0,2\rho'(1 + 2q_s)}}{1 + \sqrt{1,2\sigma'}}$$

where:

$$q_s = \frac{s_{Fn}}{2 \cdot \rho_F}$$

q_s : notch paramenter

ρ' : slip-layer thickness, mm, taken from Tab 10.

Table 10 *(1/1/2016)*

Material	ρ', in mm
Case hardened steels, flame or induction hardned steels	0,0030
through hardened steels **(1)**, yield point R_e =	
500 N/mm²	0,0281
600 N/mm²	0,0194
800 N/mm²	0,0064
1000 N/mm²	0,0014
Nitrided steels	1,1005

(1) The given values of ρ' can be interpolated for values of R_e not stated above

(1) The given values of ρ' can be interpolated for values of R_e not stated above

2.5.13 Relative surface factor $Y_{Rrel\ T}$ *(1/1/2016)*

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 $Y_{Rrel\ T}$ *(1/1/2016)*

Material	$R_Z < 1$	$1 \le R_Z \le 40$
Case-hardened steels, through-hardened steels ($\sigma_B > 800$ N/mm²)	1,120	$1,674 - 0,529\ (R_Z+1)^{0,1}$
Normalized steels ($\sigma_B < 800$ N/mm²)	1,070	$5,306 - 4,203\ (R_Z+1)^{00,1}$
Nitrided steels	1,025	$4,299 - 3,259\ (R_Z+1)^{0,0058}$

2.5.14 Size factor Y_X *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

Type of installation		S_F
Main gears (propulsion)	single machinery	1,55
	duplicate machinery	1,4
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 *(1/1/2016)*

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 *(1/1/2016)*

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/mm² for case-hardened teeth
- 800 N/mm² for induction-hardened or nitrided teeth.

3.2 Teeth

3.2.1 Manufacturing accuracy *(1/1/2016)*

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.

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.

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 mm.

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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

The shrink assembly of:

- rim and wheel body
- wheel body and shaft

is to be designed according to Sec 6.

3.3.4 Bolting *(1/1/2016)*

The bolting assembly of:

- rim and wheel body
- wheel body and shaft

is to be designed according to Sec 6.

The nuts are to be suitably locked by means other than welding.

3.4 Shafts and bearings

3.4.1 General *(1/1/2016)*

Shafts and their connections, in particular flange couplings and shrink-fit connections, are to comply with the provisions of Sec 6.

3.4.2 Pinion and wheel shafts *(1/1/2016)*

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:

$$d_s = \left\{\left[\left(10,2 + \frac{28000}{R_{Ss,min}}\right)T\right]^2 + \left[\frac{170000}{412 + R_{s,min}}M\right]^2\right\}^{\frac{1}{6}} + \left(\frac{1}{1 - K_d^4}\right)^{\frac{1}{3}}$$

where:

$R_{S,min}$: minimum yield strength of the shaft material, in N/mm²

T : nominal torque transmitted by the shaft, in Nm

M : bending moment on the shhaft, in Nm

K_d : coefficient having the following values:

- for solid shafts: $K_d = 0$
- for hallow shafts, K_d is equal to the ratio of the hole diameter to the outer shaft diameter. Where $K_d \le 0,3$: Kd = 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 *(1/1/2016)*

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 *(1/1/2016)*

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 for the nominal rating is not to 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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

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, [2.10]
   - 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 *(1/1/2016)*

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 *(1/1/2016)*

Forced lubrication systems are to be fitted with a device which efficiently filters the oil in the circuit.

3.7 Control and monitoring

3.7.1 *(1/1/2016)*

In addition to those of this item [3.7], the general requirements given in Chapter 3 apply.

In the case of yachts with automation notations, the requirements in Part E, Chapter 3 also apply.

3.7.2 *(1/1/2016)*

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 yachts with a restricted navigation notation.

4 Installation

4.1 General

4.1.1 *(1/1/2016)*

Manufacturers and shipyards 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 yacht.

4.2 Fitting of gears

4.2.1 *(1/1/2016)*

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 *(1/1/2016)*

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 6.

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 *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

Rotating components, in particular gear wheel and pinion shaft assemblies with the coupling part attached, are to undergo a static balancing test.

Where $n^2 \cdot d \geq 1{,}5.10^9$, gear wheel and pinion shaft assemblies are also to undergo a dynamic balancing test.

5.2.4 Verification of cutting accuracy *(1/1/2016)*

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 *(1/1/2016)*

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 *(1/1/2016)*

a) Hydraulic or pneumatic clutches are to be hydrostatically tested to 1,5 times the maximum working pressure of the pumps.

b) Pressure piping, pump casings, valves and other fittings are to be hydrostatically tested in accordance with the requirements of Sec 9, [13].

Table 15 : Reduction gears / reversing gears and clutch monitoring *(1/1/2016)*

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	Slowdown	Shutdown	Control	Stand by Start	Stop
Lubricating oil temperature		local					
Lubricating oil pressure		local					
	L						
Oil tank level		local					
Clutch control oil pressure	L						

6 Type approved gearing

6.1 Issue of Tasneef Type Approval Certificate

6.1.1 *(1/1/2019)*

For yachts less than 500 GT, when ✠ **MACH** class notation is to be assigned, the gearing defined in [1.1.1] as an alternative may be type approved by Tasneef

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 Tasneef 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

6.2 Renewal of Tasneef Type Approval Certificate

6.2.1 *(1/1/2019)*

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 Tasneef

SECTION 6 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.

1.2 Documentation to be submitted

1.2.1 The Manufacturer is to submit to Tasneef 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 Tasneef 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.

Table 1 : Documentation to be submitted

No	Document (drawings, calculations, etc.)
1	Shafting arrangement **(1)**
2	Thrust shaft
3	Intermediate shafts (if any)
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
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 the main propulsion system is required (see Sec 8), 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 *(1/7/2021)*

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, liners 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 sea water not by metal liners but by other protective coatings, the coating procedure is to be approved by Tasneef

2.1.6 Sterntubes

The sterntube thickness is considered by Tasneef on a case-by-case basis. In no case, however, may it be less than the thickness of the side plating adjacent to the sternframe.

Where the materials adopted for the sterntube and the plating adjacent to the sternframe are different, the sterntube thickness is to be at least equivalent to that of the plating.

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.

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:

$$d = F \cdot k \cdot \left[\frac{P}{n \cdot (1 - Q^4)} \cdot \frac{560}{R_m + 160}\right]^{1/3}$$

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 $Q \le 0,3$, Q = 0 is to be taken.

  Hollow shafts whose longitudinal axis does not coincide with the longitudinal hole axis will be specially considered by Tasneef in each case.

F : • 95 for main propulsion systems powered by diesel engines fitted with slip type couplings, by turbines or by electric motors;

- 100 for main propulsion systems powered by diesel engines fitted with other types of couplings.

k : Factor whose value is given in Tab 2 depending on 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 Tasneef 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/mm².

The scantlings of intermediate shafts inside tubes or sterntubes will be subject to special consideration by Tasneef Where intermediate shafts inside sterntubes are water lubricated, the requirements of [2.4.7] are to be applied.

2.2.3 Propeller shafts

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 Tasneef 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.

Table 2 : Values of factor k

For intermediate shafts with					For thrust shafts external to engines	
integral coupling flange	shrink fit coupling	keyways	radial bores, transverse holes	longitudinal slots	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	1,10 **(2)**	1,10 **(3)**	1,20 **(4)**	1,10	1,10

(1) Value applicable in the case of fillet radii in accordance with the provisions of [2.5.1].
(2) After 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.
(3) Value applicable in the case of diameter of bore not exceeding 0,3 d, d being as defined in **(2)**
(4) Value normally applicable in the case of slot having length not exceeding 1,4 d and width not exceeding 0,2 d, d being as defined in **(2)**, however to be justified on a case-by-case basis by the Manufacturers.

Table 3 : Values of factor K_m and R_t *(1/7/2021)*

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

The values of factor k_P to be introduced in the above formula are to be taken as follows:

a) for yachts having GT < 500

k_P : 1,04; for any portion of the propeller shaft.

b) for yachts having GT > or = 500

k_P : k_P = 1,26, for propeller shafts where:

- the propeller is keyed onto 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 onto the shaft taper by a shrinkage method in compliance with Sec 7, [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 Tasneef 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 Tasneef 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 Corrosion-resistant propeller shaft materials *(1/1/2019)*

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 3);

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 stength in torsional shear (N/mm^2) (see Tab 3).

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 for approval, axial and torsional 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 [2.2.4];

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 [2.5.5];

e) a visual inspection of the cone is required at every intermediate survey, and an inspection with a non-destructive system may be requested by the Tasneef Surveyor;

f) the use of corrosion resisting materials may be accepted only for yachts less than 300 GT.

2.2.5 Shaft bearing spacing

The maximum shaft bearing space is to be not more than the value given by the following formula:

$l = (0{,}7439 \times D)/N)^{1/2} \cdot (E/W_1)^{1/4}$

where:

l : 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.

2.2.6 Direct stress calculation method

Shaft dimensions may be approved on the basis of documentation concerning fatigue considerations, or other methods accepted by Tasneef

2.3 Liners

2.3.1 General

Metal liners or other protective coatings approved by Tasneef 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 Tasneef 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 Tasneef

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 Sterntube bearings

2.4.1 Oil lubricated aft bearings of anti-friction metal

a) The length of bearings lined with white metal or other antifriction metal and with oil glands of a type approved by Tasneef 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 material

a) For bearings of synthetic rubber, reinforced resin or plastic material which are approved by Tasneef 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.

2.4.3 Water lubricated aft bearings of lignum vitae or anti-friction metal

Where the bearing comprises staves of wood (known as "lignum vitae") or is lined with anti-friction 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) Where the bearing is constructed of synthetic materials which are approved by Tasneef for use as water lubricated sternbush bearings, such as rubber or plastics, 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 design substantiated by experimental data to the satisfaction of Tasneef 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.

2.4.5 Grease lubricated aft bearings

The length of grease lubricated bearings is generally 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 Tasneef

2.4.7 Water circulation system

For water lubricated bearings, efficient water circulation is 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 in way of the water inlet to the sterntube.

2.5 Couplings

2.5.1 Flange couplings *(1/7/2021)*

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.

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,
- 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} : Value of the minimum tensile strength of coupling bolt material, 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:
  - $R_m \leq R_{mb} \leq 1{,}7 R_m$
  - $R_{mb} \leq 1000$ 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 mentioned in (a): 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:

- yachts 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 8.

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 7, [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 Tasneef

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 [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 (ships 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 ship. 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 minimise 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 Part A, 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:

$$A = 155 \cdot \frac{d^3}{\sigma_t \cdot d_{PM}}$$

where:

- d : is the Rule diameter calculated according to the formula in [2.2.2].

In any case R_m is to be assumed equal to 400 N/mm².

- 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/mm².

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 [2.2.2].

  In any case R_m is to be assumed equal to 400 N/mm².
- 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/mm².

2.5.6 Keys and keyways of inboard shaft connections

Round ended keys are to be used and the keyways are to be provided with a smooth fillet at the bottom of the keyways. The radius of the fillet is to be at least 0,0125 of the diameter of the shaft at the coupling. The sharp edges at the top of the keyways are to be removed.

The effective area of the key in shear, A, is to be not less than:

$$A = 126 \cdot \frac{d^3}{\delta_u \cdot d_{pm}}$$

where

- d : is the Rule diameter calculated according to the formula in [2.2.2].

  In any case R_m is to be assumed equal to 400 N/mm².
- d_{pm} : is the diameter, in mm, of the cone at the middle length of the key
- δ_u : is the specified minimum tensile strength (UTS) of the key material, in N/mm².

Alternatively, consideration will be given to keys conformity to the design requirements of a recognized National Standard.

2.5.7 Tasneef may accept designs other than those stated in [2.5.5] and [2.5.6] provided that they are based on direct calculation analysis taking into account a safety factor not less than 4; alternatively, the design may be based on a recognised standard.

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 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 preheating 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 is to be suitably protected in order to prevent any contact with sea water, unless the shaft is made of corrosion-resistant material.

3.3 Shaft alignment

3.3.1 Tasneef may require the shaft alignment calculations in the case of special arrangements, for reference purposes.

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 alignment is to be checked on board by a suitable measurement method.

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 where experience shows defects are most likely to occur.

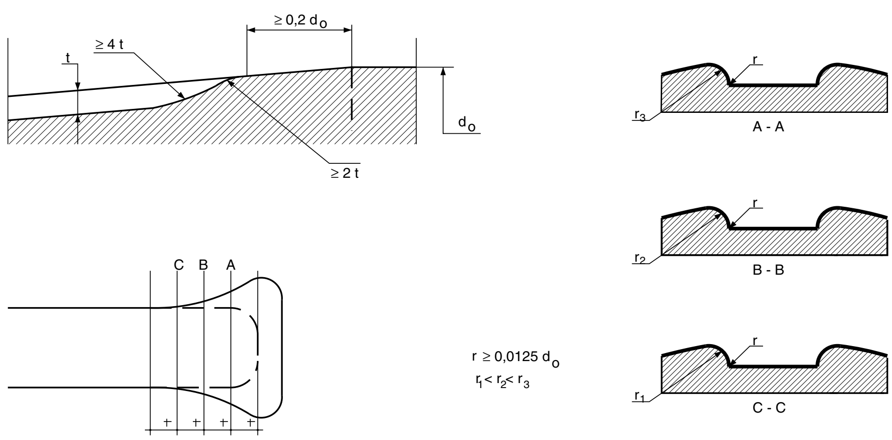
Ultrasonic testing requires the Manufacturer's signed certificate.

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.

Figure 1 : Details of forward end of propeller shaft keyway



4.2 Certification

4.2.1 Testing certification

For yachts having ✠ **MACH** class notation, Tasneef inspection certificates (see Pt D, Ch 1, Sec 1, [4.2.1] and Pt D, Ch 1, Sec 1, [4.2.2]) are required for material tests of components in items 1 to 5 of Tab 3. Works' certificates (see Part D, Ch 1, Sec 1, [4.2.3]) are requested for shafting components indicated in Tab 3 other than those for which Tasneef inspection certificates are required. For yachts with ● **MACH** class notation, works' certificates are requested for shafting components indicated in Tab 3.

4.3 Type approved main propulsion shafting

4.3.1 Issue of Tasneef Type Approval Certificate *(1/1/2019)*

For yachts less than 500 GT, when ✠ **MACH** class notation is to be assigned, the main propulsion shafting components to which this Section is applicable according to [1.1.1] as an alternative may be type approved by Tasneef

For a particular type of propulsion shafting components, 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 [4.1] and [4.2].

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.

4.3.2 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 Tasneef

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 ≥ 100 mm	if diameter ≥ 100 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) Flexible couplings (metallic parts only)	all	-	-
7)Coupling bolts or studs	all	-	-

SECTION 7 PROPELLERS

1 General

1.1 Application

1.1.1 Propulsion propellers

The requirements of this Section apply to propellers of any size and any type intended for propulsion. They include fixed and controllable pitch propellers, including those ducted in fixed nozzles.

1.1.2 Manoeuvring thruster propellers

For manoeuvring thruster propellers see Sec 11.

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.

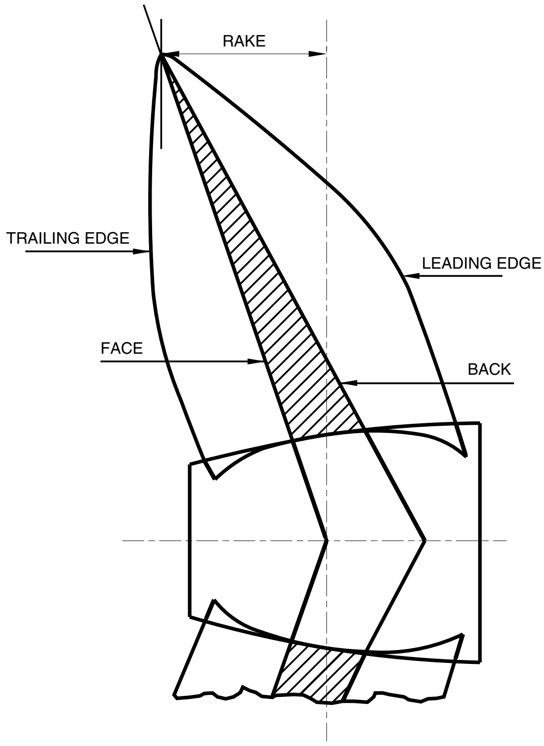
1.2.6 Rake

Rake is the horizontal distance between the line connecting the blade tip to the blade root and the vertical line crossing the propeller axis in the same point where the prolongation of the first line crosses it, taken in way of the blade tip (see Fig 1). Aft rakes are considered positive, fore rakes are considered negative.

1.2.7 Rake angle

Rake angle is the angle at any point between the tangent to the generating line of the blade at that point and a vertical line passing at the same point. If the blade generating line is straight, there is only one rake angle; if it is curved there are an infinite number of rake angles (see Fig 2).

Figure 1 : Rake



1.2.8 Skew angle

Skew angle is the angle between a ray starting at the centre of the propeller axis and tangent to the blade midchord line and a ray also starting at the centre of the propeller axis and passing at the blade tip (see Fig 3).

1.2.9 Skewed propellers

Skewed propellers are propellers whose blades have a skew angle other than 0.

1.2.10 Highly skewed propellers and very highly skewed propellers

Highly skewed propellers are propellers having blades with skew angle between 25° and 50°. Very highly skewed propellers are propellers having blades with skew angle exceeding 50°.

1.2.11 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).

1.2.12 Trailing edge

The trailing edge of a propeller blade is the edge of the blade opposite the leading edge (see Fig 1).

Figure 2 : Rake angle

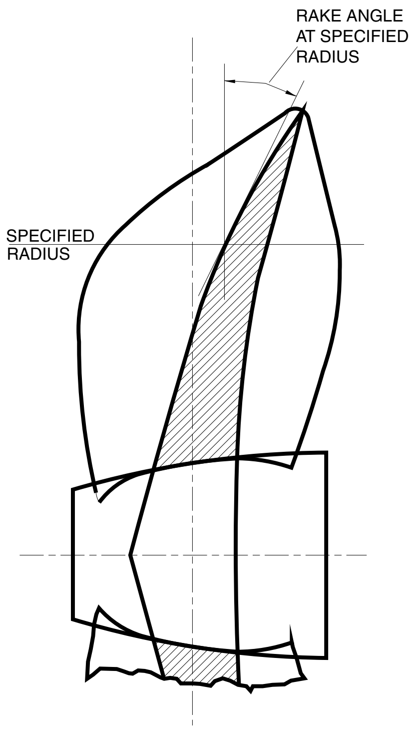
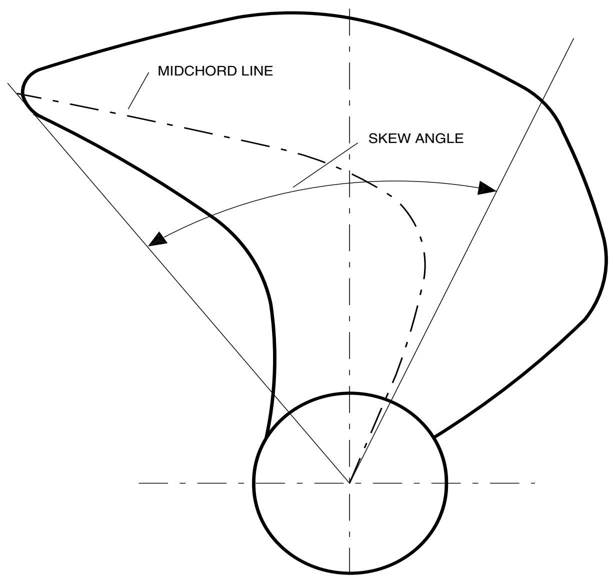


Figure 3 : Skew angle



1.2.13 Blade developed area

Blade developed area is the area of the blade surface expanded in one plane.

1.2.14 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

Nr	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 triplicate		

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

Nr	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
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 triplicate		

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/mm².

c) Other materials are subject to special consideration by Tasneef 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:

$$t_{0,25} = 2,8\left[f\cdot\frac{1,5.10^6.\rho.M_T + 51.\delta.\left(\frac{D}{100}\right)^3.B.l.N^2.h}{l\cdot z\cdot R_m}\right]^{0,5}$$

where:

- f : Material factor as indicated in Sec 8, 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 : Power, in KW, of propulsion machinery, according to Sec 1, [2.5]
- N : Rotational speed of the propeller, in rev/min
- δ : Density of blade material, in kg/dm³, as indicated in Sec 8, 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/mm².

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:

$$t_{0,6} = 1,66\left[f\,\frac{1,5.10^6.\rho_{0,6}.M_T + 18,4.\delta.\left(\frac{D}{100}\right)^3.B.l.N^2.h}{l_{0,6}\cdot z\cdot R_m}\right]^{0,5}$$

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 minimum thickness required in that position. 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 Tasneef 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 0,7 radius from the propeller axis is not to be less than that obtained from the following formula:

$$t_{0,35} = 2,36\left[f\,\frac{1,5.10^6.\rho_{0,7}.M_T + 41.\delta\left(\frac{D}{100}\right)^3 B.l_{0,35}.N^2h}{l_{0,35}\cdot z\cdot R_m}\right]^{0,5}$$

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 minimum thickness required in that position. 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 Tasneef 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

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:

$$d_{PR} = \left(\frac{4,6 . 10^7 . \rho_{0,7} . M_T + 0,88 . \delta . \left(\frac{D}{10}\right)^3 . B . l_{0,35} . N^2 . h_1}{n_{PR} \cdot z \cdot D_C \cdot R_{m,PR}} \right)^{0,5} \cdot 0,9$$

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/mm².

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°.

2.4.2 Highly skewed propellers

a) For solid and controllable pitch propellers having skew angles between 25° and 50°, 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 Tasneef 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 propeller pitch control system

a) Where the pitch control mechanism is operated hydraulically, two independent, power-driven pump sets are to be fitted. For propulsion plants up to 220 kW, one power-driven pump set is sufficient provided that, in addition, a hand-operated pump is fitted for controlling the blade pitch.

b) 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.

c) 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.

d) 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.

e) 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.

f) Tab 4 indicates the monitoring requirements to be displayed at the control console.

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 in Fig 4 is generally to be adopted for assembling the liner and propeller boss.

d) The external stuffing gland is to be provided with a sea water 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 are 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 6, [2.5.5].

3.1.2 Shrinkage of keyless propellers *(1/1/2016)*

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	:	Torque transmitted; in N.m, 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. Tasneef 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	:	Yacht speed at P power, in knots
S	:	Continuous thrust developed for free running yacht, 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/mm², 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/mm²

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/ mm²

E_M : Value of the modulus of elasticity of boss material, in N/ mm²

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/mm².

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 Tasneef

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 power P in kW, assumed as indicated in [2.2.1] 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 Tasneef

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/mm²:
  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):

$$d_T = d_{35} + \frac{d_{PM}}{2\theta} \cdot (\alpha_M - \alpha_P) \cdot (35 - T)$$

- Corresponding minimum surface pressure at temperature T:

$$p_T = p_{35} \cdot \frac{d_T}{d_{35}}$$

- Minimum push-up load temperature T:

$$W_T = A p_T \cdot (\mu + \theta)$$

- Maximum permissible surface pressure at 0°C:

$$p_{MAX} = \frac{0,7 R_{S,MIN} \cdot (K^2 - 1)}{(3K^4 + 1)^{0,5}}$$

- Corresponding maximum permissible pull-up length at 0°C:

$$d_{MAX} = d_{35} \cdot \frac{p_{MAX}}{p_{35}}$$

- Tangential force at interface:

$$F = \frac{2000 C M_T}{d_{PM}}$$

- Continuous thrust developed for free running yacht; 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 suspect 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.

4.3 Certification

4.3.1 Certification of propellers *(1/1/2020)*

Propellers having the characteristics indicated in [1.1.1] are to be individually tested and certified. Tasneef inspection certificates (see Pt D, Ch 1, Sec 1, [4.2.1] and Pt D, Ch 1, Sec 1, [4.2.2] for alternative inspection scheme) are required for material tests of propellers and each relevant component For yachts of less than 500 GT with ● **MACH** class notation, and with D < 1,5m works' certificates (see Part D, Ch 1, Sec 1, [4.2.3]) are requested.

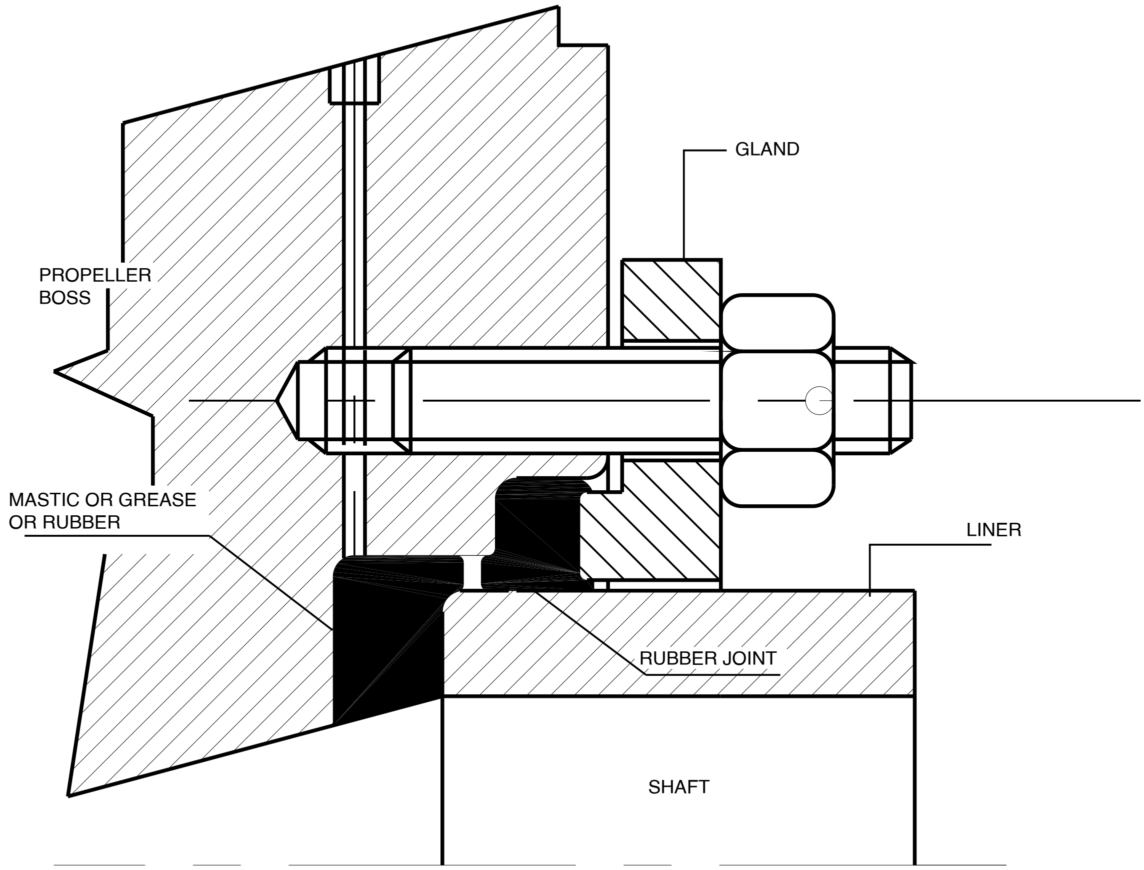
4.3.2 Mass produced propellers

Mass produced propellers may be accepted within the framework of Tasneef type approval program.

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	Indic	Slow-down	Shut-down	Control	Standby Start	Stop
Oil tank level	L						

Figure 4 : Example of sealing arrangement



4.4 Type approved propeller

4.4.1 Issue of Tasneef Type Approval Certificate *(1/1/2019)*

For yachts less than 500 GT, when ✠ **MACH** class notation is to be assigned, the propellers to which this Section is applicable according to [1.1.1] as an alternative may be type approved by Tasneef

For a particular type of propellers, 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 [4.1] and [4.2].

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.

4.4.2 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 Tasneef

SECTION 8 SHAFT VIBRATIONS

1 General

1.1 Application

1.1.1 The requirements of this Section apply to yachts for which Tasneef reserves the right to accept some plant or shaft arrangements based on the results of shaft vibrations (see Sec 6, [2.2.4]).

1.1.2 Exemptions

The requirements of this Section may be waived in cases where satisfactory service operation of similar installations is demonstrated.

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 submitted for approval and the documents listed in [4.2] are to be submitted for consideration.

2 Design of systems in respect of vibrations

2.1 Principle

2.1.1 General

a) Special consideration is to be given to the design, construction and installation of propulsion machinery systems so that no mode of their vibrations will 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.

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, 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 to existing plant

2.2.1 Where substantial modifications to existing plant, 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 6 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 plants, 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
   - allowable alternating torsional stress considered for crankpin and journal

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 6, 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, their mass moment of inertia and shaft stiffness.

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:

$$\frac{R + 160}{18}$$

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.

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.

Table 1 : Values of C_k factors

Intermediate shafts				Thrust shafts external to engines		Propeller shafts
with integral coupling flanges	with shrink-fit couplings	with keyways	splined shafts	on both sides of thrust collar	in way of axial bearing where a roller bearing is used as a thrust bearing	
1,00	1,00	0,60	0,80	0,85	0,85	0,55
Note 1: Higher values of C_k factors based on direct calculations may also be considered. **Note 2:** The determination of C_k factors for shafts other than those given in this table will be given special consideration by Tasneef						

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 Tasneef

   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 [3.5.4]. 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 0,9 N_n and 1,05 N_n. Transient running may be considered only in restricted speed ranges for speed ratios $\lambda \leq 0,9$.

   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.

Note 1: For propulsion systems operated at constant speed, restricted speed ranges related to misfiring conditions may be accepted for speed ratios $\lambda > 0,8$.

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 Tasneef 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

The torsional vibration stresses in any point of the crankshaft are not to exceed the limits established by the Manufacturer.

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:

- $\tau_1 = C_R \cdot C_k \cdot C_D \cdot C_\lambda$ for continuous running
- $\tau_2 = 1,7\ \tau_1 \cdot C_k^{-0,5}$ for transient running.

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 Restricted speed ranges

a) Where the torsional vibration stresses exceed the limit τ_1 for continuous running, restricted speed ranges are to be imposed which are to be passed through rapidly.

b) The limits of the restricted speed range related to a critical speed N_c are to be calculated in accordance with the following formula:

$$\frac{16 \cdot N_c}{18 - \lambda} \le N \le \frac{(18 - \lambda) \cdot N_c}{16}$$

c) 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.

d) 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.

e) When restricted speed ranges are imposed, the accuracy of the tachometers is to be checked in such ranges as well as in their vicinity.

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 Tasneef

b) Gear hammering induced by torsional vibration torque reversal is not permitted throughout the service speed range, except during transient running at speed ratios $\lambda \le 0,3$.

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 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.

3.6.3 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) Tasneef 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 Tasneef

3.7.2 Method of measurement

When measurements are required, the method of measurement is to be submitted to Tasneef for approval. The type of measuring equipment and the location of the measurement points are to be specified.

4 Bending vibrations

4.1 General

4.1.1 The provisions of this Article apply to the bending vibrations of propulsion systems:

- having a l/D ratio exceeding the following value:

$$10\left(\ln\frac{2}{D}\right) + D^2$$

where:

l : Span between the aft bearings of the propeller shaft, in m

D : Diameter of the propeller shaft, in m

4.2 Documentation to be submitted

4.2.1 Calculations

Bending vibration calculations are to show:

- the equivalent dynamic system used for the modelling of the plant, with indication of the mass of the shafts, propeller and other rotating components, and the lateral stiffness of the bearings, including that of the oil film and that of the seating
- the natural bending frequencies
- the values of the vibratory amplitudes and bending moments in the shafting for the most significant critical speeds
- the possible restrictions of operation of the plant.

4.2.2 Particulars to be submitted

The following particulars are to be submitted with the bending vibration calculations:

a) shafting arrangement with indication of:
   - the diameter and length of the shafts
   - the position of the bearings
   - the mounting characteristics of the cardan shafts

b) for the propeller:
   - the diametral and polar moments of inertia of the propeller in air and water
   - excitations (bending moments and bending forces).

4.3 Calculation principles

4.3.1 Scope of the calculations

a) Bending vibration calculations are to take into account:
   - the stiffness of the bearings and their seatings and, where applicable, that of the lubricating oil film
   - the excitations due to the propeller and cardan shafts.

b) Where data having a significant influence on the vibration levels cannot be determined with a sufficient degree of accuracy, parametric studies are to be carried out.

4.3.2 Criteria for acceptance of the bending vibration

The first shafting vibration mode is not to be excited by the first propeller blade excitation order in the speed range between 80% and 110% of the rated speed.

4.4 Bending vibration measurements

4.4.1 General

a) Tasneef may require bending vibration measurements in the following cases:
   - where the calculations indicate the possibility of dangerous critical speeds in the operating speed range,
   - where the accuracy of some data is not deemed sufficient, 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 Tasneef

4.4.2 Method of measurement

When measurements are required, the method of measurement is to be submitted to Tasneef for approval. The type of measuring equipment and the location of the measurement points are to be specified.

SECTION 9 PIPING SYSTEMS

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
- [12] for their certification, inspection and testing
- [3] and [4] only applicable to yachts of equal to or greater than 500 GT.

b) Specific requirements for yacht piping systems and machinery piping systems are given in [6] to [11].

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.

1.3 Definitions

1.3.1 Piping and piping systems

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.

Table 1 : Documents to be submitted

Item No	I/A **(1)**	Document **(2)**
1	A	Diagram of the bilge and ballast systems (in and outside machinery spaces)
2	A	Diagram of the air, sounding and overflow systems
3	A	Diagram of cooling systems (sea water and fresh water)
4	A	Diagram of the fuel oil system
5	A	Diagram of the lubricating oil system **(3)**
6	A	Diagram of the compressed air system

(1) A = to be submitted for approval in four copies;
(2) Diagrams are also to include, where applicable, the (local and remote) control and monitoring systems and automation systems;
(3) Only required if the system is not integral to the engine

Table 2 : Information to be submitted

Item 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 as a function of temperature • the characteristics of inflammability and fire resistance • the resistance to the products intended to be conveyed

(1) A = to be submitted for approval in four copies;
I = to be submitted for information in triplicate.

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.

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

Classes I, II and III are defined in 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.

Table 3 : Class of piping systems *(1/1/2016)*

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 **(4)**	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
Air, gases, water, non-flammable hydraulic oil **(3)**	p > 4 or T > 300	other **(2)**	p ≤ 1,6 and T ≤ 200
Open-ended pipes (drains, overflows, vents, exhaust gas lines, boiler escape pipes)			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) Valves and fittings fitted on the yacht side, bottom and collision bulkhead belong to class II.
(4) 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

Material	Allowable classes	Maximum design temperature (°C) **(1)**	Particular conditions of use
Carbon and carbon-manganese steels	III, II, I	400	Class I and II pipes are to be seamless drawn pipes **(2)**
Copper and aluminium brass	III, II, I	200	**(3)**
Copper-nickel	III, II, I	300	
Special high temperature resistant bronze	III, II, I	260	
Stainless steel	III, II, I	300	Austenitic stainless steel is not recommended to be used for sea water systems
Spheroidal graphite cast iron	III, II	350	• Spheroidal cast iron of the ferritic type according to the material Rules of Tasneef may be accepted for bilge and ballast • 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 • 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 **(4)**	220	Grey cast iron is not to be used for the following systems: • piping systems subject to shocks, high stresses and vibrations • yacht 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	200	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.

(1) Maximum design temperature is not to exceed that assigned to the class of piping.
(2) Pipes fabricated by an approved welding procedure may also be used.
(3) Pipes made of copper and copper alloys are to be seamless.
(4) Use of grey cast iron is not allowed when the design pressure exceeds 1,3 MPa.

2.1.3 Use of plastics

a) Plastics may be used for piping systems belonging to class III in accordance with App 1. The use of plastics for other systems or in other conditions will be given special consideration.

b) Plastics intended for piping systems for which there are Rule requirements are to be of a type approved by Tasneef (see Appendix 1).

c) For domestic and similar services where there are no Rule requirements, the pipes need not be of a type which has been approved. However, the fire safety aspects are to be taken into account.

d) The use of plastic pipes may be restricted by statutory requirements of the national authority of the country in which the craft is to be registered.

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 an approved welding procedure,
- specially considered by Tasneef for other welded pipes, depending on the service and the manufacturing 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 an approved welding procedure,
- equal to 12,5 for hot laminated seamless steel pipes,
- subject to special consideration by Tasneef 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.

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:

$$\frac{R_{m,20}}{2,7} \quad \frac{R_e}{A} \quad \frac{S_R}{A} \quad S$$

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

c) The permissible stress values adopted for materials other than carbon steel, alloy steel, copper and copper alloy will be specially considered by Tasneef

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
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 and over	5,9	4,5	8,8	12,7

(1) Attention is drawn to the special requirements regarding:
- bilge and ballast systems
- sounding, air and overflow pipes
- CO_2 fire-extinguishing systems (see Ch 4, Sec 11).

(2) Reinforced wall thickness applies to pipes passing through tanks containing a fluid distinct from that conveyed by the pipe.
(3) Extra-reinforced wall thickness applies to pipes connected to the shell.
Note 1: A different thickness may be considered by Tasneef 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 of coating, lining, etc, at the discretion of Tasneef 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.

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
508	4,5	4,0

Note 1: A different thickness may be considered by Tasneef 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)
8,0 to 10,0	0,8
12 to 20	1,0
25,0 to 44,5	1,2
50,0 to 76,1	1,5
88,9 to 108,0	2,0
133,0 to 159,0	2,5
193,7 to 267,0	3,0
273,0 to 457,2	3,5

Note 1: A different thickness may be considered by Tasneef 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 Tasneef 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.

2.2.3 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 centreline 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.

For stainless steel a corrosion allowance of 0,8 mm is to be used, apart from lubricating oil and hydraulic oil systems, where said value may be reduced to 0,3 mm.

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
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
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 Tasneef 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 Tasneef	

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 Tasneef

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.

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 are accomplished as double welded or by use of a backing ring or inert gas backup on first pass, or other similar methods accepted by Tasneef

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 Tasneef

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 Tasneef 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 Tasneef

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.

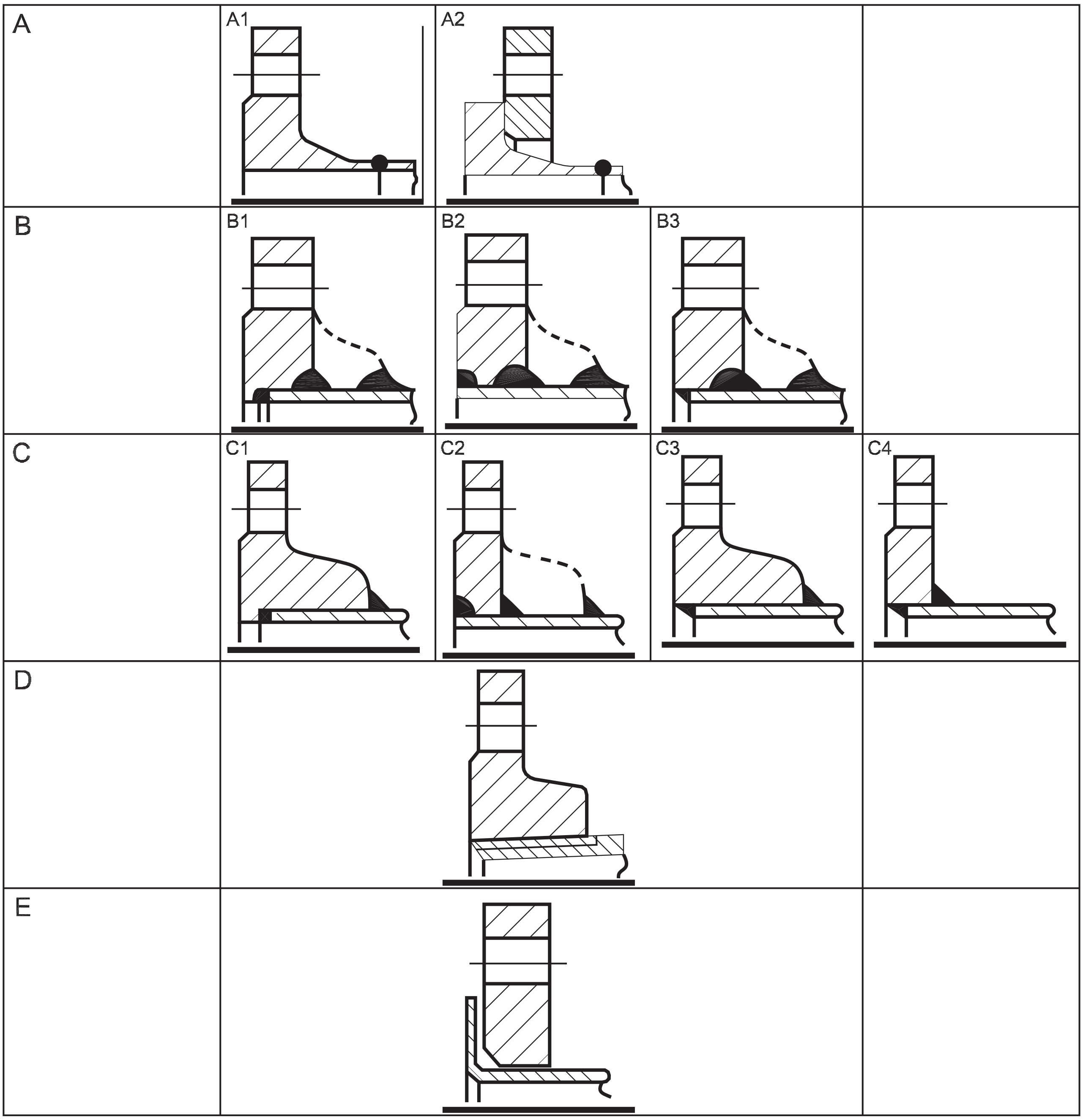
Permitted applications are indicated in Tab 14. However, Tasneef may accept flange attachments in accordance with national or international standards that are applicable to the piping system and recognise the boundary fluids, design pressure and temperature conditions, external or cyclic loading and 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 *(1/1/2019)*



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) 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
Lubricating and fuel oil	(A1)-(A2)-(B1)-(B2)-(B3)	(A1)-(A2)-(B1)-(B2)-(B3) - (C1)- (C2)-(C3)-(C4) **(5)**	(A1)-(A2)-(B1)-(B2)-(B3) -(C1)-(C2)-(C3)-(C4)
Other media, including water, air, hydraulic oil **(5)**	(A1)-(A2)-(B1)-(B2)-(B3) **(3)**	(A1)-(A2)-(B1)-(B2)-(B3) - (C1)- (C2)-(C3)-(C4)-(D) **(4)**	(A1)-(A2)-(B1)-(B2)-(B3) -(C1)-(C2)-(C3)-(C4)-(D)-(E) **(6)**

(1) The types of flange connections given in the table are those shown in Fig 1.
(2) For piping having a nominal diameter equal to or greater than 150 mm, only type (A1) and (A2) flange connections are to be adopted.
(3) Only type (A1) and (A2) flange connections are to be adopted for piping having a design temperature **T** higher than 400°C.
(4) Flange connections of types (D) and (C4) are not acceptable for piping having a design temperature **T** exceeding 250°C.
(5) For piping of hydraulic power plants of steering gear, only flange connections of types required for class I piping are to be used.
(6) 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 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 80 mm • pipes inside tanks • piping systems conveying flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.
Sleeve threaded joint (parallel thread) **(3)**	II, III	not allowed for: • pipes with outside diameter of more than 80 mm • pipes inside tanks • piping systems conveying 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 Tasneef for piping systems of classes I and II having outside diameter ≤ 88,9 mm, except for 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 Tasneef 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 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.

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.

Construction of mechanical joints is to prevent the possibility of tightness failure affected by pressure pulsation, piping vibration, temperature variation and other similar adverse effects occurring during operation on board.

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 Tasneef

In general, 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 sea openings or tanks containing flammable fluids.

Mechanical joints are to be designed to withstand internal and external pressure as applicable and where used in suction lines are to be capable of operating under vacuum.

The number of mechanical joints in oil 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 spaces which are not easily accessible, unless approved by Tasneef

The application of these joints inside tanks may be permitted only for the same media that is in the tanks.

Unrestrained slip-on joints are to be used only in cases where compensation for lateral pipe deformation is necessary. Use of these joints as the main means of pipe connection is not permitted.

Application of mechanical joints and their acceptable use for each service are indicated in Tab 16; dependence on the class of piping, pipe dimensions, working pressure and temperature 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.

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 Tasneef

For type approval, mechanical joints are to be tested at the workshop in accordance with an approved program, 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).

(Reference is to be made to the “Rules for type approval of mechanical joints”).

Figure 2 : Examples of mechanical joints

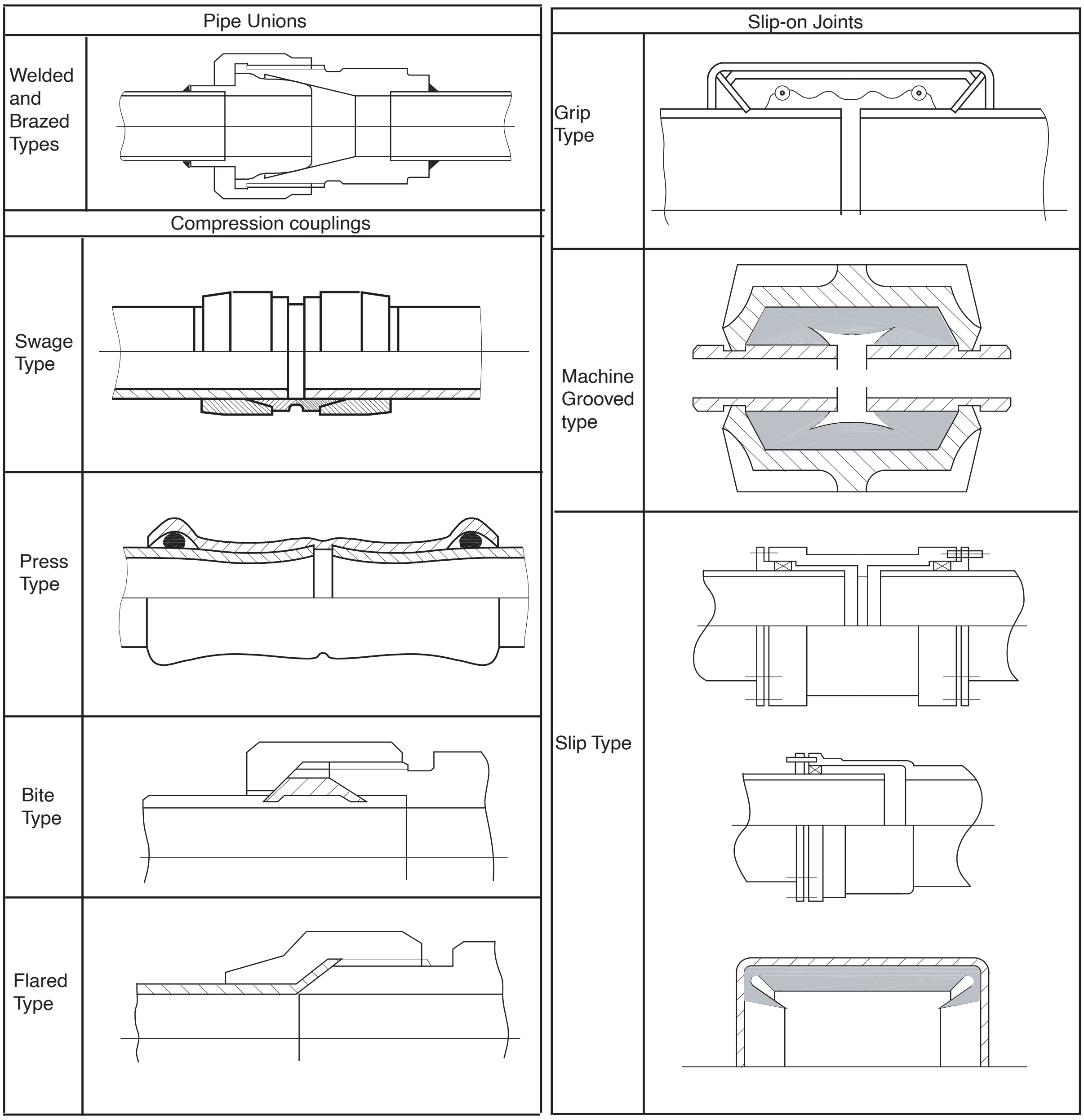


Table 16 : Application of mechanical joints

System		Kind of connections		
		Pipe Unions	Compression Couplings **(2)**	Slip-on Joints
Flammable fluids (Flashpoint > 60°)				
1	Fuel oil lines	yes	yes	yes **(1)**
2	Lubricating oil lines	yes	yes	yes **(1)**
3	Hydraulic oil	yes	yes	yes **(1)**
Sea Water				
4	Bilge lines	yes	yes	yes **(1)**
5	Fire main and water spray	yes	yes	yes **(1)**
6	Sprinkler system	yes	yes	yes **(1)**
7	Ballast system	yes	yes	yes **(1)**
8	Cooling water system	yes	yes	yes **(1)**
9	Non-essential systems	yes	yes	yes
Fresh water				
10	Cooling water system	yes	yes	yes **(1)**
11	Condensate return	yes	yes	yes **(1)**
12	Non-essential system	yes	yes	yes
Sanitary/Drains/Scuppers				
13	Deck drains (internal)	yes	yes	yes
14	Sanitary drains	yes	yes	yes
15	Scuppers and discharge (overboard)	yes	yes	yes **(3)**
Sounding/Vent				
16	Water tanks/Dry spaces	yes	yes	yes
17	Oil tanks	yes	yes	yes **(1)**
Miscellaneous				
18	Starting/Control air	yes	yes	no
19	Service air (non-essential)	yes	yes	yes
20	Brine	yes	yes	yes
21	CO_2 system	yes	yes	no
22	Steam	yes	yes	no

"yes" means application is allowed
"no" means application is not allowed

(1) Only grip type joints may be accepted inside machinery spaces of category A provided that:
- they are only for class III piping;
- they are located in an easily accessible position;
- they are fitted on a branch with maneouverable valves at the ends;
- they are approved fire-resistant types.

Outside the engine room grip type joints may be accepted if fitted in class III piping and located in an easily accessible position; the relevant fire resistance will be considered on the basis of the fire risk of the compartment where they are fitted.

(2) If compression couplings include any components which readily deteriorate in the event of fire, they are to be of approved fire-resistant type as required for slip-on joints.

(3) 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.

Table 17 : Application of mechanical joints depending on 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
Bite type Flared type	yes (outside diameter ≤ 60.3mm) yes (outside diameter ≤ 60.3mm)	yes (outside diameter ≤ 60.3mm) yes (outside diameter ≤ 60.3mm)	yes yes
Press type	no	no	yes
Slip-on joints			
Machine grooved type	yes	yes	yes
Grip type	no	yes	yes
Slip type	no	yes	yes
"yes" means application is allowed "no" means application is not allowed			

2.4 Flexible hoses and expansion joints

2.4.1 General *(1/1/2020)*

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.

For yacht in short range navigation of less than 100 GT in some systems flexible hoses may be used for the entire length in accordance with Tab.18.

Only for yachts on composite material of less than 300 GT with 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.

b) Flexible hoses and expansion joints are to be of an approved type by the Society, designed in accordance with [2.4.2] and tested in accordance with [13.2].

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 [5.8.3].

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.

2.4.2 Design of flexible hoses and expansion joints *(1/1/2019)*

a) Flexible pipes 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, hydraulic and thermal 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 for use in steam systems are to be of metallic construction.

f) 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.

g) 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.

h) Flexible hoses and expansion joints are to be so designed as to withstand the bursting pressure requeste by the "Rules for the type approval of flexible hoses and expansion joints".

i) 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 [20.2.1] are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to installation.

j) 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 and 15541. For the fire endurance test of non metallic flexible hoses for yachts having GT<100, in short range navigation see Tab 18.

k) 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.

2.4.3 Conditions of use of flexible hoses and expansion joints *(1/1/2019)*

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 ship side and the valves mentioned in [2.6.3] 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.

Table 18 : Fire endurance of non-metallic flexible hoses for Yachts < 100 GT *(1/1/2019)*

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 **(1)**			
Cooling Water, Essential Services	FT	FT	FT
Ballast	FT	FT	FT
FIRE SYSTEM **(1)**			
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			
Deck Drains (Internal)	FT	0	0
Sanitary Drains (Internal)	0	0	0

(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, boilers, steam 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
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, boilers, steam 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.

2.5 Valves and accessories

2.5.1 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.

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.

2.5.2 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.

2.5.3 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.

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.

2.6 Sea inlets and overboard discharges

2.6.1 General

The requirements of this item do not apply to scuppers and sanitary discharges.

2.6.2 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 [2.5] and [2.6.3].

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 [2.6.4].

f) Sea chests are to be suitably protected against corrosion.

2.6.3 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 the same scantlings, 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 Tasneef 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] Tab 4.

f) Vessel side valves serving piping systems made of plastics are to comply with App 1.

2.6.4 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.

2.6.5 Through hull fitting

When the passage through the hull of sea inlets and overboard discharges is designed with a metallic cylindrical stem, 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 19.

Table 19

External diameter (mm)	Minimum wall thickness (mm)
20,0	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

A different wall thickness may be considered by Tasneef 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 Tasneef

2.7 Control and monitoring

2.7.1 General

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.

2.7.2 Level gauges

Level gauges used in flammable oil systems are subject to the following conditions:

- their failure or overfilling of the tank is not to permit release of fuel into the space. The use of cylindrical gauges is prohibited. Tasneef 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.

2.8 Protection against overpressure

2.8.1 General *(1/1/2016)*

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.

b) Safety valves are to be sealed after setting.

2.8.2 Protection of flammable oil systems *(1/1/2016)*

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.

2.8.3 Protection of pump and compressor discharges *(1/1/2016)*

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.

2.8.4 Protection of pipes *(1/1/2016)*

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 [2.7.1].

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%.

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 Tasneef

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.

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 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.

3.4.2 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 20 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 are to be made with an electrode suitable for the base metal; tack welds which form part of the finished weld are to be made using approved procedures.

   When welding materials requiring preheating are employed, the same preheating is to be applied during tack welding.

Table 20 : 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
$150 \leq d < 300$	1,0	1,5	1,5
$300 \leq d$	1,0	1,5	2,0

3.4.3 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.

3.4.4 Preheating

a) Preheating is to be performed as indicated in Tab 21, depending on the type of steel, the chemical composition and the pipe thickness.

b) The temperatures given in Sec 10, Tab 19 are based on the use of low hydrogen processes. Where low hydrogen processes are not used, Tasneef reserves the right to require higher preheating temperatures.

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.

Table 21 : 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 ≥ 20 **(2)**	50
	$C + \frac{Mn}{6} > 0,40$	t ≥ 20 **(2)**	100
0,3 Mo		t ≥ 13 **(2)**	100
1 Cr 0,5 Mo		t < 13 t ≥ 13	100 150
2,25 Cr 1 Mo **(1)**		t < 13 t ≥ 13	150 200
0,5 Cr 0,5 Mo V **(1)**		t < 13 t ≥ 13	150 200

(1) For 2,25 Cr 1 Mo and 0,5 Cr 0,5 Mo 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 Tasneef

(2) For welding in ambient temperature below 0°C, the minimum preheating temperature is required independent of the thickness unless specially approved by Tasneef

Table 22 : 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 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 Tasneef

(2) For 2,25Cr 1Mo and 0,5Cr 0,5Mo 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 Tasneef

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 22, 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

3.5.3 Heat treatment after oxyacetylene welding

Stress relieving heat treatment after oxyacetylene welding is to be performed as indicated in Tab 23, depending on the type of steel.

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 b).

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.

Table 23 : 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

3.6.2 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 X-ray 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 Part D for the special quality level,
   - for class II pipes, those defined in Part D 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

Unless otherwise justified, 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.

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 22 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 23 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 23 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 the yacht.

5.2 Location of tanks and piping system components

5.2.1 Pipe lines located inside tanks

a) The passage of pipes through tanks, when permitted, normally requires special arrangements such as reinforced thickness 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 flange connections. See also [2.3.2] and [2.3.3].

5.2.2 Piping and electrical apparatus

As far as possible, pipes are not to pass near switchboards or other electrical apparatus. If this requirement is impossible to satisfy, gutterways or masks are to be provided wherever deemed necessary to prevent projections of liquid or steam on live parts. Where it is not possible to comply with the above requirement either, drip trays or shields are to be provided as deemed necessary.

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) Penetrations of watertight bulkheads or decks by plastic pipes are to comply with App 1, [3.6.2].

5.3.2 Passage through the collision bulkhead

Pipes passing through the collision bulkhead below the main deck are to be fitted with suitable valves abaft the collision bulkhead. All valves are to be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable. The valves are to be always readily accessible for prompt use.

5.4 Prevention of progressive flooding

5.4.1 Principle

a) In order to comply with the subdivision and damage stability requirements when applicable, 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.

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.

5.5 Provision for expansion

5.5.1 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 pipe material
- the deformation of the yacht's hull.

5.5.2 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.

5.6 Supporting of the pipes

5.6.1 General

Unless otherwise specified, the fluid lines referred to in this Section are to consist of pipes connected to the yacht's structure by means of collars or similar devices.

5.6.2 Arrangement of supports

Shipyards are to ensure that:

a) the arrangement of supports and collars is 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 independently supported.

5.7 Protection of pipes

5.7.1 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 generally not to exceed 3 m/s.

d) If copper pipes are used for sea water systems, the water velocity is generally not to exceed 2 m/s.

e) Arrangements are to be made to avoid galvanic corrosion.

5.7.2 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 Valves, accessories and fittings

5.8.1 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.

5.8.2 Valves and accessories

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.

5.8.3 Flexible hoses and expansion joints *(1/1/2019)*

a) Flexible hoses and expansion joints are to be so arranged as to be clearly visible and in readily accessible location.

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 or 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.

5.8.4 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.

5.8.5 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.

5.8.6 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.

5.9 Additional arrangements for flammable fluids

5.9.1 General

The requirements in [5.9.2] and [5.9.3] 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.

5.9.2 Prevention of flammable oil leakage ignition

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.

5.9.3 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 and leakages on heated surfaces.

b) Drip trays with adequate drainage to contain possible leakage from flammable fluid systems are to be fitted:
   - under independent tanks
   - 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.

5.9.4 Valves

All valves and cocks forming part of flammable oil systems are to be capable of being operated from readily accessible positions.

6 Bilge systems

6.1 Principle

6.1.1 General

The requirements of this Chapter are to be applied to yachts less than 500 GT. For yachts of 500 GT and over, reference is to be made to Pt C, Ch 1, Sec 10 of the Rules for the Classification of Ships.

In any case, for yachts of 500 GT and over, the minimum requirements for vessels of less than 500 GT contained in this paragraph are also to be met. In addition, for such yachts the capacity of pumps and size of the bilge main and branches are to meet the requirements for passenger ships contained in SOLAS.

An efficient bilge pumping system is to 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.

The bilge pumping system is not intended to cope with water ingress resulting from structural or main sea water piping damage.

If deemed acceptable by Tasneef bilge pumping arrangements may be dispensed with in specific compartments provided the safety of the yacht is not impaired.

6.1.2 Availability of the bilge system

The bilge pumping units, or pumps, may also be used for ballast, fire or general service duties of an intermittent nature, but they are to be immediately available for bilge duty when required.

6.2 Design of bilge systems

6.2.1 General

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 [6.4.3] and [6.4.4].

6.2.2 Number and distribution of bilge suctions

a) Draining of watertight spaces is to be possible, when the yacht is on an even keel and either is upright or has a list of up to 10°, by means of at least:
   - two suctions in machinery spaces with propulsion prime mover, including one branch bilge suction and one emergency bilge suction
   - one suction in other spaces.

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 Direct bilge suction in engine room

For vessels having GT > 300, in addition to the suctions given in [6.2.2] a), a direct suction is required in machinery spaces with a propulsion prime mover.

6.2.4 Prevention of communication between spaces - Independence of the lines

Bilge lines are to be so arranged as to avoid inadvertent flooding of any dry compartment.

Generally bilge lines are to be entirely independent and distinct from other lines.

A non-return valve is to be fitted between each bilge pump and the bilge main.

6.3 Draining of machinery spaces

6.3.1 General

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 [6.3.4].

6.3.2 Branch bilge suction

The branch bilge suction is to be connected to the bilge main. Non-return valves are to be fitted in each branch bilge suction from the main bilge line.

6.3.3 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 yachts where, in the opinion of Tasneef 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 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.

6.3.4 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 slopes 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) In electrically propelled yachts, provision is to be made to prevent accumulation of water under electric generators and motors.

6.3.5 Number and distribution of suctions in boiler and auxiliary machinery spaces

In auxiliary compartments, one bilge suction is to be provided.

6.3.6 Bilge suction from stabilizer compartment/box *(1/1/2016)*

If the stabilizer are located in a watertight compartment, a dedicated bilge suction from the main bilge manifold is to be foreseen. The stabilizer compartment is to be also suitably vented.

If the stabilizers are located in accordance with Part.B, Ch.1, Sec 2, [4.2] in a small watertight box and the machinery inside the box do not need ventilation, the above mentioned bilge suction and ventilation are not required. A self-closing valve on a vertical side for the drainage of the watertight box may be accepted.

A bilge alarm is to be in any case foreseen.

6.4 Draining of dry spaces other than machinery spaces

6.4.1 General

Except where otherwise specified, bilge suctions are to be branch bilge suctions, i.e. suctions connected to a bilge main.

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.

b) Drainage of the after peak may be effected by means of a self-closing cock fitted in a well-lighted and readily accessible position.

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 design draught, the bilge suctions of the steering gear compartment are to be connected to the main bilge system.

c) The compartments referred to in b) above may be drained by scuppers discharging to the machinery space in the case of yachts with machinery aft and fitted with self-closing cocks situated in well-lighted and visible positions.

6.4.5 Draining of spaces where fuel oil or other liquid with high fire risk may be collect

Pumping and piping arrangements for bilges into which fuel or other oils of similar or higher fire risk could collect, under either normal or fault conditions, are to be kept clear of accommodation spaces and separate from accommodation bilge systems. Bilge level alarms meeting the requirements of [6.7.5] are to be fitted to all such bilges.

6.5 Bilge pumps

6.5.1 Number and arrangement of pumps *(1/1/2017)*

a) At least two fixed and independently powered pumps are to be provided.

   Such pumps are to be fitted in two different compartment and they are to be fed by two different sources of power supplies. For short range yachts, the second pump and suction pipes may be portable.

   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) 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].

c) when the two pumps are both fixed, they are to have each its dedicated suction piping from each watertight compartment and its dedicated overboard discharge. 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.

d) the emergency bilge pump may be the same pump as the emergency fire pump provided that they can satisfy the requirement of both the system.

e) 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 other 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

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].

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.

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.

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.

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.

6.6 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 : Rule length of the yacht, in m.

B : Greatest insulated breadth of the yacht

D : Moulded depth of the yacht to the bulkhead deck, in m.

b) 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
- less than that required for any branch bilge suction.

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

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 Sec 10, [6.6.1]

L_1 : Length of the compartment, in m.

6.6.4 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 in the case of motor yachts.

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.

6.6.5 Scuppers in aft spaces

Any scupper provided for draining aft spaces is to have an internal diameter not less than 35 mm.

6.7 Bilge accessories

6.7.1 Drain valves on watertight bulkheads

The fitting of drain valves or similar devices is not allowed on the collision bulkhead.

6.7.2 Screw-down non-return valves

Accessories are to be provided to prevent intercommunication of compartments or lines which are to remain segregated from one another. For this purpose, screw-down 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 each branch bilge
- at the open end of bilge pipes passing through deep tanks
- in compliance with the provisions for the prevention of progressive flooding, if applicable.

6.7.3 Mud boxes *(1/1/2017)*

In machinery spaces of yacht having GT > or = 500, if considered necessary by the Surveyor, termination pipes of bilge suctions are to be straight and vertical and are to be led to mud boxes so arranged as to be easily inspected and cleaned.

The lower end of the termination pipe is not to be fitted with a strum box.

6.7.4 Strum boxes

a) In compartments other than machinery spaces, 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 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 wheelhouse. The audible and visual alarm may be accepted elsewhere if it is considered that such a location may by more appropriate.

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 have reinforced thickness, as per Tab 5 for steel pipes.

The thickness of pipes made from materials other than steel will be specially considered.

6.8.2 Passage through tanks

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 have reinforced thickness, as per Tab 5 for steel pipes, and are to be made either of one piece or several pieces assembled by welding, by reinforced flanges or by devices deemed equivalent for the application considered; the number of joints is to be as small as possible.

6.8.3 Provision for expansion

Where necessary, bilge pipes inside tanks are to be fitted with expansion bends.

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 are to be in positions which are accessible under ordinary circumstances

Hand-wheels of valves controlling emergency bilge suctions are to be readily accessible and easily manoeuvrable. It is is preferable for them to rise above the manoeuvring floor.

7 Air, sounding and overflow pipes

7.1 Air pipes

7.1.1 Principle

Air pipes are to be fitted to all tanks, double bottoms, cofferdams, 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.

7.1.2 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. When the top of the compartment is of irregular form, the position of air pipes will be given special consideration by Tasneef

7.1.3 Location of open ends of air pipes

a) Air pipes of double bottom compartments 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 main deck.

Note 1: In yachts not provided with a double bottom, air pipes of small cofferdams or tanks not containing fuel oil or lubricating oil may discharge within the space concerned.

b) Air pipes of tanks intended to be pumped up are to be led to the open air above the main deck.

c) Air pipes of tanks may discharge through the side of the superstructure.

d) The location of air pipes for flammable oil tanks is also to comply with [7.1.7].

7.1.4 Height of air pipes

a) The height of air pipes is to be in compliance with the minimum value indicated in Part B.

   This height is to be measured from the upper face of the deck, including sheathing or any other covering, up to the point where water may penetrate inboard.

b) Where these heights may interfere with the working of the yacht, a lower height may be approved, provided Tasneef 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. In any case, where lower heights are proposed their acceptance is subject to the flag Administration.

c) The height of air pipes may be required to be increased on yachts for the purpose of compliance with damage calculations.

7.1.5 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 ensure a weathertight closure.

   Means of closure may be omitted if it can be shown that the open end of an air pipe is afforded adequate protection by other superstructure which will prevent the ingress of water.

b) Automatic weathertight closing appliances are to be fitted in the following cases:

   - where, with the yacht at its design draught, 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 [7.1.4], item b), air pipes have a height lower than that required in Part B.

7.1.6 Design of closing appliances

When closing appliances are requested to be of an automatic type, they are to be of a type acceptable to Tasneef and are to be tested in accordance with a national or international standard recognised by Tasneef

7.1.7 Special arrangements for air pipes of flammable oil tanks

a) Air and overflow pipes and relief valves of fuel oil systems are to discharge to a position where there is no risk of fire or explosion from the emergence of oils and vapour and are not to lead into accommodation and crew spaces, machinery spaces or similar spaces.

   The open ends are to be fitted with wire gauze diaphragms which are made of corrosion-resistant material and readily removable for cleaning and replacement. The clear area of such diaphragms 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.

7.1.8 Construction of air pipes

a) Where air pipes to ballast and other tanks extend above the main deck, the exposed parts of the pipes are to be of substantial construction.

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 38 mm; a lower value may be accepted for small tanks but in no case less than 25 mm.

e) Air pipes to fuel oil, lubricating oil and other tanks containing flammable liquids which are located in or pass through compartments of high fire risk or on open deck are to be steel or other material recognised suitable for that location.

7.2 Sounding pipes

7.2.1 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) The following systems may be accepted in lieu of sounding pipes for compartments that are readily accessible at all times:

- a level gauge efficiently protected against shocks, or
- a remote level gauging system.

7.2.2 Position of sounding pipes

Sounding pipes are to be located as close as possible to suction pipes.

7.2.3 Termination of sounding pipes

a) As a general rule, sounding pipes are to end above the main deck in easily accessible places and are to be fitted with efficient, permanently attached closing appliances.

b) In machinery spaces, 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 yachts required to be fitted with a double bottom, such closing appliances are to be of the self-closing type.

7.2.4 Special arrangements for sounding pipes of flammable oil tanks

Where sounding pipes are used in flammable oil systems, they are to terminate where no risk of ignition of spillage from the sounding pipe might arise. As a general rule, they are not to terminate in machinery spaces. However, where Tasneef considers that this requirement is impracticable, it may permit termination in machinery spaces on condition that the following provisions are satisfied:

The terminations of sounding pipes are to be 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.

Sounding pipes may terminate in accommodation and crew spaces provided that the relevant tank is fitted with a remote gauging system and the sounding pipe is used in an emergency only.

7.2.5 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 Tasneef Such 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.

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.

7.3 Overflow pipes

7.3.1 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 [7.1.8], item d).

7.3.2 Design of overflow systems

a) Overflow pipes are to be led:

- either outside,
- or, in the case of fuel oil or lubricating oil or flammable oil, to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

b) Where tanks are connected to a common overflow system, the arrangement is to be such as to prevent any risk of 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 design draught 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 design draught 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 design draught.

7.3.3 Overflow tanks

a) Overflow tanks are to have an adequate capacity sufficient to receive the delivery of the pumps.

b) Overflow tanks are to be fitted with an air pipe complying with [7.1] 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 Tasneef

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.

7.3.4 Specific requirements for construction of overflow pipes

a) The internal diameter of overflow pipes is not to be less than 38 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.

7.4 Constructional requirements applying to sounding, air and overflow pipes

7.4.1 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.

7.4.2 Minimum thickness of pipes

The thickness of air pipes fitted on exposed decks is to be equivalent to that of the adjacent hull structures.

7.4.3 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 be of reinforced thickness, in accordance with Tab 5.

7.4.4 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.

7.4.5 Nameplates

Nameplates are to be fixed at the upper part of air pipes and sounding pipes.

8 Cooling systems

8.1 Application

8.1.1 This Article applies to all cooling systems using the following cooling media:

- sea water
- fresh water

Air cooling systems will be given special consideration.

8.2 Principle

8.2.1 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.

8.3 Design of sea water cooling systems

8.3.1 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 [8.5.1], item b).

8.3.2 Centralised cooling systems *(1/1/2020)*

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 of the main cooling pump

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.

8.3.3 Individual cooling of propulsion engines

Individual cooling systems of propulsion engines are to include at least:

- one main cooling water pump, which can be driven by the engine
- a second means of cooling.

For motor yachts the second means may consist of:

- a connection to an independently driven pump, such as a suitable sea water pump of sufficient capacity, provided arrangements against overpressure in the cooling system are made

- 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.

8.3.4 Individual cooling of auxiliary engines and other essential equipment

Where each auxiliary engine is served by its own cooling circuit, no second means of cooling is required.

8.4 Design of fresh water cooling systems

8.4.1 General

For vessels having fresh water cooling systems external to the engines, such systems will be specially considered.

Fresh water cooling systems are to be designed according to the Manufacturer's technical specification.

8.4.2 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.

8.5 Arrangement of cooling systems

8.5.1 Sea inlets

a) At least two sea inlets complying with [2.7] are to be provided for the cooling system.

b) The two sea inlets may be connected by a cross-over supplying both the main cooling pump and standby cooling pump.

c) 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.

8.5.2 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.

8.5.3 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.

b) Where general service pumps or other pumps may be connected to a cooling system, arrangements are to be made to avoid overpressure in any part of the cooling system.

8.5.4 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.

8.5.5 Materials *(1/1/2020)*

In general, piping and associated accessories are to be made of steel resistant to salt water corrosion and to be galvanically compatible. The use of piping made of non-metallic materials may be accepted under the conditions listed in

App 1.

9 Fuel oil systems

9.1 Application

9.1.1 Scope

This Article applies to all fuel oil systems supplying any kind of installation.

9.1.2 Requirements applying to fuel oil systems and not contained in this Section

Additional requirements are given:

- for the location and scantling of tanks forming part of the yacht's structure, in Part B
- for helicopter refuelling facilities, in Pt C, Sec 9, [6].

9.2 Principle

9.2.1 General

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 of fuel oil.

c) Fuel oils used for engines are to have a flashpoint complying with the provisions of Section 1.

9.3 General

9.3.1 Arrangement of fuel oil systems

a) In a yacht 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 [5.9] are to be complied with.

9.3.2 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.

9.3.3 Ventilation

The ventilation of machinery spaces is to be sufficient under all normal conditions to prevent accumulation of oil vapour.

9.3.4 Access

Spaces where fuel oil is stored or handled are to be readily accessible.

9.4 Design of fuel oil filling and transfer systems

9.4.1 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.

9.4.2 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 [7.3.3] or to other safe positions deemed satisfactory.

9.4.3 Independence of fuel oil transfer lines

The fuel oil transfer piping system is to be completely separate from the other piping systems of the yacht.

9.4.4 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, which may be manual,
- 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.

9.5 Arrangement of fuel oil tanks

9.5.1 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 and electrical apparatus.

b) Fuel oil tanks are not to be situated in locations where they could be subjected to high temperatures, unless specially agreed by Tasneef

c) As far as practicable, fuel oil tanks are to be part of the yacht's structure. In craft constructed of aluminium or other heat sensitive material, the tanks are to be suitably protected against the effect of fire in the machinery space.

9.5.2 Use of free-standing fuel oil tanks

Where free-standing tanks are fitted in machinery spaces they are to comply with Part B and be positioned in an oil tight drip tray of ample size having suitable drainage arrangements to a spill oil tank.

9.6 Design of fuel oil tanks

9.6.1 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 item [9.6], and in particular regarding the valve requirements.

9.6.2 Filling and suction pipes

a) All suction pipes from fuel oil tanks, 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 such 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 [9.6.3].

9.6.3 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 situated above the double bottom is to be fitted with a cock or valve directly on the tank capable of being closed locally and from a safe position outside the space in which such tanks are situated in the event of a fire occurring in such space.

b) Such valves and cocks are also to include local control and indicators are to be provided on the remote and local controls to show whether they are open or shut; (see [2.5.3]).

9.6.4 Drain pipes

Fuel oil tanks are to be fitted with drain pipes, provided with self-closing valves or cocks.

9.6.5 Air and overflow pipes

Air and overflow pipes are to comply with [7.1] and [7.3].

9.6.6 Sounding pipes and level gauges

Safe and efficient means of ascertaining the amount of fuel oil contained in any fuel oil tank are to be provided; (see also [7.2.4]).

9.7 Design of fuel oil treatment systems

9.7.1 Drains

a) Settling tanks or, where settling tanks are not provided, 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.

b) Where drain cocks or valves are fitted to fuel oil tanks, they are to be of the self-closing type and suitable provision is to be made for collecting the oil discharge.

9.7.2 Purifiers

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.

b) Subject to special consideration by Tasneef 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.

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.

9.8 Design of fuel supply systems

9.8.1 Fuel oil supply to internal combustion engines and gas turbines

All external high pressure fuel delivery lines between the high pressure fuel pumps and fuel nozzles are to be protected with a jacketed tubing system capable of containing fuel resulting from a high pressure line failure. The jacketed tubing system is to include means of collection of leakage and arrangements are to be provided for an alarm to be given in the event of a fuel line failure.

a) The suctions of engine fuel pumps are to be so arranged as to prevent the pumping of water and sludge likely to accumulate after decanting at the lower part of service tanks.

b) Suitable filters are to be provided on the fuel oil line to the injection pumps.

   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. These filters are to be provided with a metal bowl.

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 are to be so located that in the event of a leakage the fuel oil cannot be pulverised onto the exhaust manifold.

d) When a fuel oil booster pump is fitted which is essential to the operation of the main engine, either a standby pump, connected ready for immediate use, or a complete spare pump of appropriate capacity ready to be connected, is to be provided.

e) 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.

f) 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.

g) 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.

h) In multi-engine installations which are supplied from the same fuel source, means 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.

9.9 Control and monitoring

9.9.1 Monitoring

Alarms and safeguards are to be provided for fuel oil systems in accordance with Tab 24.

9.9.2 Remote controls

a) The remote control arrangement of valves fitted on fuel oil tanks is to comply with [9.6.3].

b) The power supply to:
   - transfer pumps and other pumps of the fuel oil system,
   - and fuel oil purifiers (if any)

   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.
   - 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.

9.10 Construction of fuel oil piping systems

9.10.1 Materials

Internal galvanisation of fuel oil pipes and tank or bunker walls is to be avoided.

9.11 Arrangement of fuel oil piping systems

9.11.1 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 have a reinforced thickness complying with Tab 5. Material other than steel will be specially considered.

9.11.2 Passage of pipes through fuel oil tanks

Boiler feed water and fresh water pipes are not to pass through fuel oil tanks, unless such pipes are contained within tunnels.

Table 24 : Fuel oil systems

Symbol convention H = High L = Low X = function is required	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indica-tion	Slow-down	Shut-down	Control	Standby Start	Stop
Fuel oil overflow tank level	H **(1)**						
Fuel oil temperature after heaters (if applicable)	H **(3)**	local		X **(4)**			
Fuel oil settling tank and service tank temperature (if applicable)	H **(2)**	local					
Fuel oil level in daily service tank	L+H **(1)**	local					
Fuel oil daily service tank temperature	H **(2)**	local					
(1) Or sight-flow glass on the overflow pipe **(2)** Applicable where heating arrangements are provided **(3)** Or low flow alarm in addition to temperature control when heated **(4)** Cut off of electrical power supply when electrically heated							

10 Lubricating oil systems

10.1 Application

10.1.1 This Article applies to lubricating oil systems serving diesel engines, gas turbines, reverse and reduction gears, clutches and controllable pitch propellers, for lubrication or control purposes.

10.2 Principle

10.2.1 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.

b) Lubricating oil systems are to be so designed as to ensure sufficient 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.

10.3 General

10.3.1 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 [5.9] are to be complied with, where applicable.

10.3.2 Filtration

a) In forced lubrication systems, a device is to be fitted which efficiently filters the lubricating oil in the circuit.

b) 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.

10.3.3 Purification

Where provided, lubricating oil purifiers are to comply with [9.7.2].

10.4 Design of engine separate lubricating oil systems

10.4.1 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 with 2 or more engines, each with its own lubricating pump, a spare pump ready to be connected to the lubricating oil system is to be supplied provided disassembling and reassembling operations can be carried out on board in a short time. This spare pump need not be provided if disassembling is not practicable on board.

10.4.2 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, the availability of a spare pump will be considered on case-by-case.

10.5 Design of oil lubrication, oil control and oil cooling systems for other equipment

10.5.1 Control of controllable pitch propellers and clutches

a) Separate oil systems intended for the control of:
   - controllable pitch propellers, or
   - clutches

   are to include at least two power pumps, of such a capacity as to maintain normal control with any one pump out of action.

b) In the case of propulsion plants comprising:
   - more than one shaft line with the propellers and/or the clutches fitted with their own control system, 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 oil control system, provided disassembling and reassembling operations can be carried out on board in a short time.

c) 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 and clutches provided that they are so designed as to be fixed mechanically in the "forward" position or in the "clutched" position and that the capacity of the starting means ensures the numbers of starts required in such conditions.

10.6 Design of lubricating oil tanks

10.6.1 Remote control of valves

Oil tanks for separate lubricating systems as per [10.4] with a capacity of 500 litres and above are to be fitted with remote control valves in accordance with the provisions of [9.6.3]. 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 control 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.

10.6.2 Filling and suction pipes

Filling and suction pipes are to comply with the provisions of [9.6.2].

10.6.3 Air and overflow pipes

Air and overflow pipes are to comply with the provisions of [7.1] and [7.3].

10.6.4 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 [7.2].

c) Oil-level gauges complying with [2.7.2] may be used in place of sounding pipes.

d) Gauge cocks for ascertaining the level in the tanks are not to be used.

10.7 Construction of lubricating oil piping systems

10.7.1 Materials

Materials used for oil piping systems in machinery spaces are to comply with the provisions of [9.10.1].

10.7.2 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.

11 Exhaust gas systems

11.1 General

11.1.1 Application

This Article applies to:
- exhaust gas pipes from engines and gas turbines
- smoke ducts from boilers and incinerators.

11.1.2 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.

11.2 Design of exhaust systems

11.2.1 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.

11.2.2 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 vessel 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].

11.2.3 Limitation of pressure losses

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 or boiler Manufacturers.

11.2.4 Intercommunication of engine exhaust gas lines or boiler smoke ducts

a) Exhaust gas from different engines is not to be led to a common exhaust main, exhaust gas boiler or economiser, unless each exhaust pipe is provided with a suitable isolating device.

11.2.5 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 ship.

b) Where exhaust pipes are water-cooled, they are to be so arranged as to be self-draining overboard.

11.3 Materials

11.3.1 General

Materials of exhaust gas pipes and fittings are to be resistant to exhaust gases and suitable for the maximum temperature expected.

11.3.2 Use of plastics

The use of non-metallic materials may be accepted in water-cooled systems in accordance with the provisions of App 1.

11.4 Arrangement of exhaust piping systems

11.4.1 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 turbochargers.

b) The devices used for supporting the pipes are to allow their expansion or contraction.

11.4.2 Provision for draining

a) Drains are to be provided where necessary in exhaust systems, and in particular in exhaust ducting below exhaust gas boilers, 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.

11.4.3 Flexible hoses

The use of flexible hoses in water-cooled exhaust systems will be given special consideration by Tasneef

11.4.4 Silencers

Engine silencers are to be so arranged as to provide easy access for cleaning and overhaul.

12 Compressed air systems

12.1 General

12.1.1 Application *(1/1/2016)*

This Article applies to compressed air systems intended for essential services, and in particular to:

- starting of engines,
- control and monitoring.

12.2 Principle

12.2.1 General *(1/1/2016)*

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.

12.2.2 Avalability *(1/1/2016)*

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.

12.3 Design of starting air systems

12.3.1 Initial charge of starting air receivers *(1/1/2016)*

a) Where, for the purpose of [12.2.2], 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 [12.2.2] 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.

12.3.2 Number and capacity of air compressors *(1/1/2016)*

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, [3.1.1]. This capacity is to be approximately equally divided between the number of compressors fitted, excluding the emergency compressor fitted in pursuance of [12.3.1].

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).

12.3.3 Initial charge of starting air receivers *(1/1/2016)*

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, [3.1.1]. 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.

12.3.4 Air supply for starting the emergency generating set *(1/1/2016)*

Starting air systems serving main or auxiliary engines may be used for starting the emergency generator under the conditions specified in Sec 2, [3.1.3].

12.4 Design of control and monitoring air systems

12.4.1 Air supply *(1/1/2016)*

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.

12.4.2 Pressure control *(1/1/2016)*

Arrangements are to be made to maintain the air pressure at a suitable value in order to ensure satisfactory operation of the installation.

12.4.3 Air treatment *(1/1/2016)*

In addition to the provisions of [12.8.3], arrangements are to be made to ensure cooling, filtering and drying of the air prior to its introduction in the monitoring and control circuits.

12.5 Design of air compressors

12.5.1 Prevention of excessive temperature of discharged air *(1/1/2016)*

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°.

12.5.2 Prevention of ovepressure *(1/1/2016)*

a) Air compressors are to be fitted with a relief valve complying with [2.8.3].

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.

12.5.3 Crankcase relief valves *(1/1/2016)*

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, [2.1.3].

12.5.4 Provision for draining *(1/1/2016)*

Air compressors are to be fitted with a drain valve.

12.6 Control and monitoring of compressed air systems

12.6.1 General *(1/1/2016)*

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 E, Chapter 3 also apply.

12.6.2 Monitoring *(1/1/2019)*

Alarms and safeguards are to be provided for compressed air systems in accordance with Tab 25.

Note 1: Some departures from Tab 25 may be accepted by the Society in the case of yachts with a restricted navigation notation.

12.6.3 Automtic controls *(1/1/2016)*

Automatic pressure control is to be provided for maintaining the air pressure in the air receivers within the required limits.

12.7 Materials

12.7.1 *(1/1/2016)*

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.

12.8 Arrangement of compressed air piping systems

12.8.1 Prevention of overpressure *(1/1/2016)*

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.

12.8.2 Air supply to compressors *(1/1/2016)*

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.

12.8.3 Air treatment and draining *(1/1/2016)*

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.

12.8.4 Lines between compressors, receivers and engines *(1/1/2016)*

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.

12.8.5 Protective devices for starting air mains *(1/1/2016)*

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, [3.1.1].

Table 25 : Compressed air systems *(1/1/2016)*

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	Indica-tion	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							

13 Use of reductants in SCR systems

13.1

13.1.1 Use of aqueous and anydrous ammonia *(1/1/2018)*

Aqueous and Anydrous ammonia are 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.

Use of Anydrous ammonia is to be agreed with the Flag Administration.

13.1.2 Use of urea based ammonia *(1/1/2023)*

Where urea based ammonia (e.g. AUS 40 - aqueous urea solution specified in ISO 18611-1) 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 ship, this may necessitate the fitting of heating and/or cooling systems. The physical conditions recommended by applicable recognized standards (such as ISO 18611-3) 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 supply and exhaust ventilation system 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 .

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.

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 ship's stability calculation.

The above 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.

The reductant piping and venting systems are to be independent of other ship 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. 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.

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 vessels provided that the integral tanks are coated and/or insulated with a self-extinguishing material.

For the protection of crew members, the ship is to have on board suitable personnel protective equipment. Eyewash and safety showers 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.

14 Hydraulic systems

14.1 Application

14.1.1 Hydraulic installations intended for essential services *(1/1/2023)*

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 and
- bow visors
- manoeuvring systems of mobile ramps, movable platforms, elevators and telescopic wheelhouses
- starting systems of diesel engines and gas turbines
- remote control of valves.

14.1.2 Hydraulic installations located in spaces containing sources of ignition *(1/1/2023)*

Hydraulic power installations not serving essential services but located in spaces where sources of ignition are present are to comply with the provisions of [14.3.2], [14.3.3], [14.4.3] and [14.4.4].

14.1.3 Low pressure or low power hydraulic installations *(1/1/2023)*

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 Tasneef

14.1.4 Very high pressure hydraulic installations *(1/1/2023)*

Hydraulic power installations with a design pressure exceeding 35 MPa will be given special consideration by Tasneef

14.2 Principle

14.2.1 General *(1/1/2023)*

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.

14.2.2 Availability *(1/1/2023)*

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.

14.3 General

14.3.1 Definitions *(1/1/2023)*

Power unit: is the assembly formed by the hydraulic pump and its driving motor

Actuator : is a component which directly converts hydraulic pressure into mechanical action

14.3.2 Limitations of use of hydraulic oils *(1/1/2023)*

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.

14.3.3 Location of hydraulic power units *(1/1/2023)*

a) Whenever practicable, hydraulic power units are to be located outside main engine or boiler 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.

14.4 Design of hydraulic systems

14.4.1 Power units *(1/1/2023)*

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 ship may be accepted, except for steering gear.

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.

14.4.2 Filtering equipment *(1/1/2023)*

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.

14.4.3 Provision for cooling *(1/1/2023)*

Where necessary, appropriate cooling devices are to be provided.

14.4.4 Provision against overpressure *(1/1/2023)*

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.

14.4.5 Provision for venting *(1/1/2023)*

Cocks are to be provided in suitable positions to vent the air from the circuit.

14.5 Design of hydraulic tanks and other components

14.5.1 Hydraulic oil service tanks *(1/1/2023)*

a) Service tanks intended for hydraulic power installations supplying essential services are to be provided with at least:
- a level gauge complying with [2.7.2]
- a temperature indicator
- a level switch complying with [14.6.3].

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.

14.5.2 Hydraulic oil storage tanks *(1/1/2023)*

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.

14.5.3 Hydraulic accumulators *(1/1/2023)*

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.

14.6 Control and monitoring

14.6.1 General *(1/1/2023)*

The general requirements given in Chapter 3 apply in addition to those in [14.6].

In the case of yachts with automation notations, the requirements in Part E also apply.

14.6.2 Indicators *(1/1/2023)*

Arrangements are to be made for connecting a pressure gauge where necessary in the piping system.

14.6.3 Monitoring *(1/1/2023)*

Alarms and safeguards for hydraulic power installations intended for essential services, except steering gear, for which the provisions of Sec 10 apply, are to be provided in accordance with Tab 26.

Note 1: Some departures from Tab 26 may be accepted by the Society in the case of yachts with a restricted navigation notation.

Note 2: Tab 26 does not apply to steering gear.

Table 26 : Hydraulic oil systems *(1/1/2023)*

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	Indica-tion	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.							

14.7 Construction of hydraulic oil piping systems

14.7.1 Materials *(1/1/2023)*

a) Pipes are to be made of seamless steel. The use of welded steel pipes will be given special consideration by Tasneef

b) Casings of pumps, valves and fittings are to be made of steel or other ductile material.

15 Certification, inspection and testing of piping systems

15.1 Application

15.1.1 Items [15.2] to [15.6] define the certification and workshop inspection and testing program to be performed on piping systems to be fitted on board of yachts for which the ✠ **MACH** notation is required.

In addition, all yachts are to be subjected to the onboard testing as defined in Sec 14.

15.1.2 On yachts for which the ● **MACH** notation is required, all inspections and tests required in these paragraphs [15.2] to [15.6] are to be carried out at the workshop under the responsibility and supervision of the Manufacturers are to be provided.

15.2 Type tests

15.2.1 Type tests of flexible hoses and expansion joints *(1/1/2019)*

a) Type approval tests are to be carried out on flexible hoses or expansion joints of each type and of sizes in accordance with Tab 27 (see also the "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.

15.3 Testing of materials

15.3.1 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.

15.3.2 Tests for materials *(1/1/2019)*

a) Where required in Tab 28, 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
   - 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 1.

Table 27 : 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
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) Tasneef reserves the right to require the vibration test in cases of installation of the components on sources of high vibrations.
(3) only for flexible hoses conveying low temperature fluids.
(4) Tasneef reserves the right to require the cyclic expansion test for piping systems subjected to expansion cycles
(5) resistance 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.

15.4 Hydrostatic testing of piping systems and their components

15.4.1 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 Tasneef for acceptance prior to testing.

15.4.2 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 compressed air pipes, and fuel oil and other flammable oil pipes with a design pressure greater than 0,7 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 it is necessary to avoid excessive stress in way of bends, branches, etc., Tasneef 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 testing of piping is carried out on board, these tests may be carried out in conjunction with the tests required in [13.4.7]

15.4.3 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 Tasneef at a pressure not less than 1,5 times the design pressure p defined in [1.3.2].

b) Valves and through hull fittings intended to be fitted on the yacht side 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 3.

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.

15.4.4 Hydrostatic tests of fuel oil tanks not forming part of the yacht's structure

Fuel oil tanks not forming part of the yacht's structure are to be subjected to a hydrostatic test under a pressure corresponding to 2 m above the tank top or the height of the overflow pipe, whichever is the greater.

15.4.5 Hydrostatic tests of pumps and compressors

Where $p \geq 1.6\ MP_a$:

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 Sec 10, [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.

15.4.6 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 twice the maximum service pressure, subject to a minimum of 1 MPa.

b) During the test, the flexible hose or expansion joint is to be repeatedly deformed from its geometrical axis.

15.4.7 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, liquid 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.

15.5 Testing of piping system components during manufacturing

15.5.1 Pumps

Bilge and fire pumps are to undergo a performance test.

15.5.2 Centrifugal separators

Centrifugal separators used for fuel oil and lubricating oil are to undergo a running test, normally with a fuel water mixture.

15.6 Inspection and testing of piping systems

15.6.1 The inspections and tests required for piping systems and their components are summarised in Tab 28.

Table 28 : Inspection and testing at works for piping systems and their components

N°	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	Type of product certificate	
1	Valves, pipes and fittings						
	a) class I, d ≥ 32 mm or class II, d ≥ 200 mm	X	C	X **(5)**	X	C **(3)**	[15.4.1] [15.4.2]
	b) class I, d < 32 mm or class II, d < 200 mm	X	W	X **(5)**	X	W	[15.4.3]
2	Flexible hoses and expansion joints	X **(6)**	W		X	C **(3)**	[15.2.1] [15.4.6]
3	Pumps and compressors						
	a) all				X	C **(3)**	[15.4.5]
	b) bilge and fire pumps				X	C **(3)**	[15.5.1]
4	Centrifugal separators				X	C **(3)**	[15.5.2]

(1) X = test is required
(2) C = class certificate
W = works' certificate
(3) or alternative type of certificate, depending on the Inspection Scheme; see Part D.
(4) where required by Sec 10, [11.4.2].
(5) if of welded construction.
(6) if metallic.

15.7 Certification

15.7.1 Testing certification

For yachts with the ✠**MACH** class notation, Tasneef inspection certificates (see Pt D, Ch 1, Sec 1, [4.2.1] and Pt D, Ch 1, Sec 1, [4.2.2] for alternative inspection scheme) are required for piping systems and their components as required in Tab 28.

For yachts with the ● **MACH** class notation, works' certificates (according to Pt D, Ch 1, Sec 1, [4.2.3]) will be accepted for piping systems and their components as required in Tab 28.

For valves and through hull fittings intended to be arranged on the side of yachts with the ● **MACH** class notation, if the nominal diameter is more than 80 mm, a class certificate is to be required. For diameter ≤ 80 mm, Tasneef type approval as per [15.8.1] may be accepted.

15.8 Type approved piping system components

15.8.1 Issue of Tasneef Type Approval Certificate *(1/1/2019)*

For yachts less than 500 GT, when ✠ **MACH** class notation is to be assigned, the piping system components to which this Section is applicable are to be type approved by Tasneef

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 [13].

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.

15.8.2 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 Tasneef

SECTION 10 STEERING GEAR

1 General

1.1 Application

1.1.1 Scope

Unless otherwise specified, the requirements of this Section apply to the steering gear systems of the yachts covered by these Rules, and to the steering mechanism of thrusters used as means of propulsion.

1.2

1.2.1 Unless expressly provided otherwise, every yacht is to be provided with main steering gear and indipendent auxiliary steering gear to the satisfaction of Tasneef

1.3 Documentation to be submitted

1.3.1 Documents to be submitted for all steering gear

Before starting construction, all plans and specifications listed in Tab 1 are to be submitted to Tasneef for approval.

1.4 Definitions

1.4.1 Main steering gear

Main steering gear is the machinery, actuators, steering gear power units, if any, and ancillary equipment and the means of applying torque necessary for effecting movement of the rudder for the purpose of steering the yacht under design conditions.

Table 1 : Documents to be submitted for steering gear

Item No	Status of the review **(2)**	Description of the 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 and manoeuvring characteristics for which the yacht has been designed
3	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
4	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
5	A	Diagrams of the electric power circuits
6	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
7	A	Constructional drawings of the strength parts providing 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
8	I/A	For azimuth thrusters used as steering means, the specification and drawings of the steering mechanism and, where applicable, documents 1 to 7 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) Submission of the drawings may be requested:
for approval, shown as "A"; for information, shown as "I".

1.4.2 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.

1.4.3 Auxiliary steering gear

Auxiliary steering gear means a power unit independent from the main steering gear and its associated piping systems to the actuator(s). The actuator, tiller and other components beyond the tiller need not be duplicated.

Auxiliary steering gear may be activated by a hard-operated system, provided that the requirements of [2.1.2] are complied with.

1.4.4 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.

1.4.5 Rudder actuator

Rudder actuator is the component which directly converts hydraulic pressure into mechanical action to move the rudder.

1.4.6 Steering gear control system

Steering gear control system is the equipment by which orders are transmitted from the control station 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.

1.4.7 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 [2.1.1].

1.5 Symbols

1.5.1 *(1/1/2020)*

The following symbols are used for the strength criteria of steering gear components:

d_s : Rule diameter of the rudder stock in way of the tiller, in mm, as defined in Pt B, Ch 1, Sec 6, assuming $k_1 = 1$

T_R : Rule design torque of the rudder stock given, in kN.m, by the following formula:

$$T_R = 13{,}5 \cdot d_s^3 \cdot 10^{-6}$$

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)

R : Value of the minimum specified tensile strength of the material at ambient temperature, in N/mm^2

R_e : Value of the minimum specified yield strength of the material at ambient temperature, in N/mm^2

R'_e : Design yield strength, in N/mm^2, determined by the following formula:

- $R'_e = R_e$, where $R = 1{,}4\ R_e$
- $R'_e = 0{,}417\ (R_e+R)$ 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 is to be:

a) capable of putting the rudder over from 35° on one side to 35° on the other side in not more than 30s with the yacht at its deepest seagoing draught and running ahead at maximum ahead service speed.

   Based on the type of the proposed steering system the above angle 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.

   For planning hulls with conventional rudders the possibility to accept a reduction of the steering angle is based on the possibility to assure adequate manovrability conditions at lower speed.

   In addition, the main steering gear is to be capable of putting the rudder from 35° on either side to 30° on the other side in not more than 28 seconds;

b) operated by power where necessary to meet the requirements of a) and in any case when Tasneef requires a rudder stock of over 120 mm diameter in way of the tiller, and

c) so designed that it will not be damaged at maximum astern speed; however, this design requirement need not be proved by trials.

2.1.2 Auxiliary steering gear

The auxiliary steering gear is to be of adequate strength and capable of steering the yacht at navigable speed and of being brought speedily into action in an emergency.

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 so arranged that after a single failure in its piping system or in one of the power units, the defect can be isolated so that steering capability can be maintained or speedily regained.

Steering gear other than of the hydraulic type is to achieve standards equivalent to the requirements of this paragraph to the satisfaction of Tasneef

2.1.3 In addition to [2.1.2], for yachts having GT > or = 500, the auxiliary steering gear is to be capable of putting the rudder over from 15° on one side to 15° on the other side in not more than 60s with the vessel at its deepest seagoing draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater, and operated by power where necessary to meet the above-mentioned requirements or when the rudder stock in way of the tiller is greater than 150 mm.

2.1.4 Hand operation

Hand-operated auxiliary steering gear is acceptable when the rudder stock in way of the tiller is less than 150 mm.

2.2 Mechanical components

2.2.1 General

a) All steering gear components and the rudder stock are to be of sound and reliable construction to the satisfaction of Tasneef

b) 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.

2.2.2 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 Tasneef It is not permitted for cylinders. The use of other metallic material will be considered on a case-by-case basis.

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.

2.2.3 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:

   $$Z_b = \frac{0,147 \cdot d_s^3}{1000} \cdot \frac{L'}{L} \cdot \frac{235}{R'_e}$$

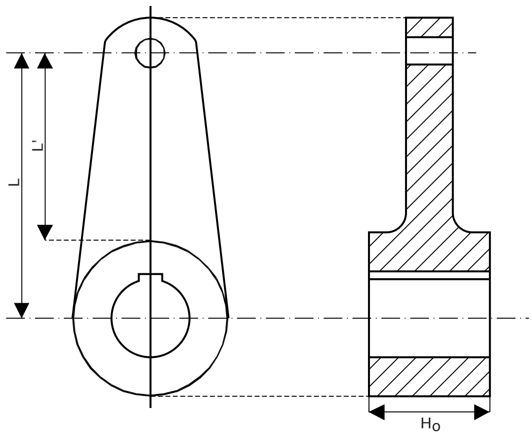
   where:

   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 Tasneef 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:

$$d_b = 153\sqrt{\frac{T_R}{n(b+0,5d_{se})}\cdot\frac{235}{R_{eb}}}$$

   where:

   n : Number of bolts located on the same side in respect of the stock axis (n is not to be less than 2)

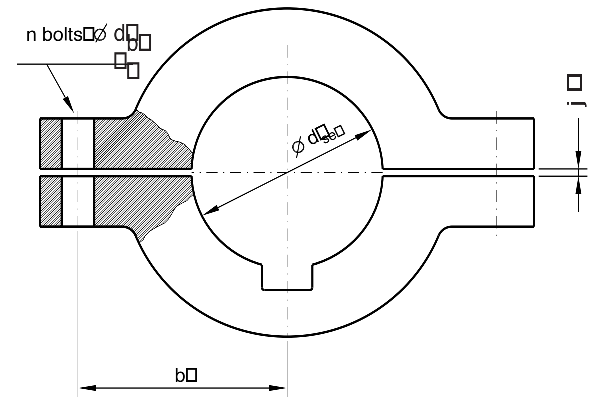
   b : Distance between bolts and stock axis, in mm (see Fig 2)

   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:

$$j = 0,0015 \cdot d_s$$

Figure 2 : Bolted tillers



e) Shrink-fit connections of tiller (or rotor) to stock are to satisfy the following provisions:
   - the safety factor based on the Rule design torque T_R 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 Tasneef

   - the entrance edge of the tiller bore and that of the rudder stock cone are to be rounded or bevelled.

2.3 Hydraulic system

2.3.1 General

a) The design pressure for calculations to determine the scantlings of piping and other steering gear components subjected to internal hydraulic pressure is to be at least 1,25 times the maximum working pressure to be expected under the operational conditions specified in [3] taking into account any pressure which may exist in the low pressure side of the system.

   At the discretion of Tasneef 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) Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

c) The hydraulic system intended for main and auxiliary steering gear is to be independent of all other hydraulic systems of the yacht.

d) The hydraulic piping system, including joints, valves, flanges and other fittings, is to comply with the requirments of Sec 9 for class I piping systems.

2.3.2 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.

2.3.3 Isolating valves

Shut-off valves, non-return valves or other suitable devices are to be provided to comply with the availability requirements of [2.3.5].

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.

2.3.4 Flexible hoses

Flexible hoses may be installed between two points where flexibility is required, but are not to be subjected to torsional deflection (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.

2.3.5 Relief valves

a) Relief valves are to be fitted to any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source or from external forces. The setting of the relief valves is not to exceed the design pressure. The valves are to 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.

2.3.6 Hydraulic oil reservoirs

Hydraulic power-operated steering gear is to be provided with a low level alarm for each hydraulic fluid reservoir to give the earliest practicable indication of hydraulic fluid leakage. Audible and visual alarms are to be given on the wheelhouse.

2.3.7 Filters

a) Hydraulic power-operated steering gear is to 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.

2.3.8 Rudder actuators

a) Rudder actuators are to be designed in accordance with the relevant requirements of Sec 3 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 2.

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.

Table 2 : Value of coefficients A and B

Coefficient	Steel	Cast steel	Nodular cast iron
A	3,5	4	5
B	1,7	2	3

2.4 Electrical systems

2.4.1 Application

The requirements of this item [2.4] apply to electric power-operated steering gear.

2.4.2 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.

2.4.3 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.

b) 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.

2.4.4 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 converters.

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.

2.4.5 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.

2.4.6 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.

g) Power units motor controllers and other automatic motor controllers are to be fitted with under-voltage release.

2.4.7 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.

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.

2.5 Alarms and indications

2.5.1 Power units

a) In the event of a power failure to any one of the steering gear power units, an audible and visual alarm is to be given on the wheelhouse.

b) Means for indicating that the motors of electric and electrohydraulic steering gear are running are to be installed on the wheelhouse.

c) Where a three-phase supply is used, an alarm is to be provided that will indicate failure of any one of the supply phases (only for yachts having GT > or = 500).

d) An overload alarm is to be provided for each motor of electric or electrohydraulic steering gear power units (only for yachts having GT > or = 500).

e) The alarms required in c) and d) are to be both audible and visual and situated in a conspicuous position in the wheelhouse.

2.5.2 Hydraulic system

a) Hydraulic oil reservoirs are to be provided with the alarms required in [2.3.6].

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.

This item b) does not apply to units having gross tonnage less than 500.

2.5.3 Control system

In the event of a failure of electrical power supply to the steering gear control systems, an audible and visual alarm is to be given on the navigating bridge (only for yachts having GT > or = 500).

2.5.4 Rudder angle indication

The angular position of the rudder is to be:

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 to be supplied through the emergency switchboard;

b) recognisable in the steering gear compartment.

2.5.5 Summary table

Displays and alarms are to be provided in the locations indicated in Tab 3.

3 Control of the steering gear

3.1 General

3.1.1 Control of the main steering gear

a) Control of the main steering gear is to be provided on the navigation bridge.

b) Where the main steering gear is arranged in accordance with [2.1.2] (two or more identical power units), two independent control systems are to be provided, both operable from the navigation bridge. This does not require duplication of the steering wheel or steering lever.

3.1.2 Control of the auxiliary steering gear

a) Control of the auxiliary steering gear is to be provided on the navigation bridge, in the steering gear compartment or in another suitable position.

b) If the auxiliary steering gear is power operated, its control system is also to be independent of that of the main steering gear.

3.2 Main and auxiliary steering gear control (GT > or = 500)

3.2.1 This item [3.2] applies only to vessels having gross tonnage of equal to or greater than 500.

3.2.2 Steering gear control is to be provided:

a) for the main steering gear, both in the wheelhouse and in the steering gear compartment

b) where the main steering gear is arranged in accordance with [2.1.2], by two independent control systems, both operable from the navigation bridge and the steering gear compartment, where applicable. 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.

Table 3 : Location of displays and alarms

Item	Display	Alarms (audible and visible)	Location	
			Navigation Bridge	Steering gear compartment
Power failure of each power unit		X	X	
Indication that electric motor of each power unit is running	X		X	
Overload of electric motor of each power unit (yachts having GT > or = 500)		X	X	
Phase failure of electric motor of each power unit (yachts having GT > or = 500)		X	X	
Low level of each hydraulic fluid reservoir		X	X	
Power failure of each control system (yachts having GT > or = 500)		X	X	
Hydraulic lock (yachts having GT > or = 500)		X	X	
Rudder angle indicator	X		X	X

3.3 Control systems operable from the navigation bridge

3.3.1 This item [3.3] applies only to vessels having gross tonnage of equal to or greater than 500.

3.3.2 Any main and auxiliary steering gear control system operable from the navigation bridge is to comply with the following:

- if electrical, it is to be served by its own separate circuit supplied from a steering gear power circuit from a point within the steering gear compartment, or directly from switchboard busbars supplying that steering gear power circuit at a point on the switchboard adjacent to the supply to the steering gear power circuit,
- means are to be provided in the steering gear compartment where applicable for disconnecting any control system operable from the wheelhouse from the steering gear it serves,
- the system is to be capable of being brought into operation from a position in the wheelhouse,
- in the event of failure of electrical power supply to the control system, an audible and visual alarm is to be given in the wheelhouse, and
- short-circuit protection only is to be provided for steering gear control supply circuits.

4 Design and construction - Requirements for yachts equipped with thrusters as steering means

4.1 Principle

4.1.1 General

The main and auxiliary steering gear referred to in [4] above may consist of thrusters of the following types:

- azimuth thrusters
- water-jets
- cycloidal propellers

complying with the provisions of Sec 11, as far as applicable.

4.1.2 Actuation system

Thrusters used as steering means are to be fitted with a main actuation system and an auxiliary actuation system.

4.1.3 Control system

Where the steering means of the yacht consists of two or more thrusters, their control system is to include a device ensuring 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.

4.2 Use of water-jets

4.2.1 The use of water-jets as steering means will be given special consideration by Tasneef

5 Arrangement and installation

5.1 Overload protection

5.1.1 Rudder angle limiters

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.

5.2 Means of communication

5.2.1 If steering systems can also be operated from other positions in addition to the wheelhouse, then two-way communication is to be arranged between the bridge and these other positions.

6 Certification, inspection and testing

6.1 Testing and certification

6.1.1

Items [6.1] to [6.3] apply to testing steering gear.

For yachts having ✠ **MACH** notation, Tasneef inspection certificates (see Pt D, Ch 1, Sec 1, [4.2.1] and Pt D, Ch 1, Sec 1, [4.2.2] for alternative inspection scheme) are required.

Works' certificates (Pt D, Ch 1, Sec 1, [4.2.3]) are accepted for yachts for which the ● **MACH** notation is required.

6.1.2 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.

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.

6.1.3 Hydraulic piping, valves and accessories

Tests for materials of hydraulic piping, valves and accessories are to comply with the provisions of Sec 9, [13].

6.2 Inspection and tests during manufacturing

6.2.1 Components subject to pressure or transmitting mechanical forces

a) The mechanical components referred to in [6.1.2] are to be subjected to appropriate non-destructive tests. For hydraulic cylinder shells, pump casings and accumulators, refer to Sec 3.

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.

6.2.2 Hydraulic piping, valves and accessories

Hydraulic piping, valves and accessories are to be inspected and tested during manufacturing in accordance with Sec 9, [13], for a class I piping system.

6.3 Inspection and tests after completion

6.3.1 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 9, [13].

6.3.2 Shipboard tests

After installation on board the yacht, the steering gear is to be subjected to the tests detailed in Sec 14, [3.8].

6.3.3 Sea trials

For the requirements of sea trials, refer to Sec 14.

6.4 Type approved steering gear

6.4.1 Issue of Tasneef Type Approval Certificate *(1/1/2019)*

For yachts less than 500 GT, when ✠ **MACH** class notation is to be assigned, the steering gear defined in [1.1.1] a) and b) as an alternative may be type approved by Tasneef

For a particular type of steering gear, 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 [6.1], [6.2] and [6.3].

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.

6.4.2 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 Tasneef

SECTION 11 THRUSTERS

1 General

1.1 Application

1.1.1 The requirements of this Section apply to thrusters intended for propulsion, steering and developing power equal to 375 kW or more; for power less than 375 kW the requirements apply only to the propeller and associated shaft when intended for yachts having the ✠ **MACH** notation.

1.1.2 Thrusters when intended for yachts to be assigned the ✠ or ● **MACH** notation and for the ratings in [1.1.1] are to be designed according to the criteria given in [2] and delivered with the Manufacturer's statement of compliance with the said criteria and with the works' certificates (see Pt D, Ch 1, Sec 1, [4.2.3]).

1.1.3 All other thrusters are to be designed and constructed according to sound marine practice and delivered with the relevant works' certificates.

1.2 Definitions

1.2.1 Thruster

A thruster is a propeller installed in a revolving nozzle or in a special transverse tunnel in the yacht, or a water-jet. A thruster may be intended for propulsion, manoeuvring and steering or any combination thereof. Propulsion propellers in fixed nozzles are not considered thrusters.

1.2.2 Transverse thruster

A transverse thruster is an athwartship thruster developing a thrust in a transverse direction for manoeuvring purposes. Accordingly, item [2.2.6] is to be complied with.

1.2.3 Azimuth thruster

An azimuth thruster is a thruster which has the capability to rotate through 360° in order to develop thrust in any direction.

1.2.4 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.

1.3 Thrusters intended for propulsion

1.3.1 In general, at least two azimuth thrusters are to be fitted in yachts where these are the sole means of propulsion. Single azimuth thruster installations will be specially considered by Tasneef 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 athwartship thrusters and azimuth thrusters

For thrusters intended for propulsion and steering, 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.

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 7.

2.1.2 Other thruster components

For 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.

2.2 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.

2.2.2 Propellers

For propellers of thrusters intended for propulsion, steering and dynamic positioning, the requirements of Sec 7 apply.

2.2.3 Shafts

a) For propeller shafts of thrusters, the requirements of Sec 6 apply to the portion of propeller shaft 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 5, [3.4.2] apply.

Table 1 : Plans to be submitted for athwartship 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 7
3	A	Bearing details
4	A	Propeller and intermediate shafts
5	A	Gears, including the calculations according to Sec 5 for cylindrical gears or standards recognised by Tasneef 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
Specific requirements for rotating and azimuth thrusters		
8	A	Structural items (nozzle, bracing, etc.)
9	A	Structural connection to hull
10	A	Rotating mechanism of the thruster
11	A	Thruster control system
12	A	Piping systems connected to thruster
(1) A = to be submitted for approval in four copies I = to be submitted for information in triplicate		

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
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 triplicate		

Table 3 : Data and documents to be submitted for athwartship 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		

2.2.4 Gears

Gears of thrusters intended for propulsion and steering are to be in accordance with the applicable requirements of Sec 6 for cylindrical gears or standards recognised by Tasneef for bevel gears, applying the safety factors for propulsion gears.

2.2.5 Nozzles and connections to hull for azimuth thrusters

a) For the requirements relative to the nozzle structure, see Pt B, Ch 1, Sec 2.

b) The scantlings of the nozzle connection to the hull and the welding type and size will be specially considered by Tasneef 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 Pt B, Ch 1, Sec 2.

2.2.6 Transverse thruster tunnel

a) For the thickness of the tunnel reference is to be made to Pt B, Ch1, Sec 2 (5.1).

b) Special consideration will be given by Tasneef to tunnels connected to the hull by connecting devices other than welding.

2.2.7 Bearings

Bearings are to be identifiable and are to have a life adequate for the intended purpose. However, their life cannot be less than 2000 hours for continuous duty thrusters.

2.2.8 Electrical supply for steerable thrusters

The generating and distribution system is to be designed in such a way that the steering capability of the thruster can be maintained or regained within a period of 45 seconds, in the event of single failure of the system, and that the effectiveness of the steering capability is not reduced by more than 50% under such conditions. Details of the means provided for this purpose are to be submitted to Tasneef

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:

$$d_2 = 100fh \cdot \left(\frac{P}{N}\right)^{1/3}$$

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/mm²

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 to special consideration by Tasneef

2.3.3 Steering performance

Steering performance and emergency steering availability are to be at least equivalent to the requirements in Sec 10.

2.4 Alarm, monitoring and control systems

2.4.1 Steering thruster controls

a) Controls for steering are to be provided from the wheelhouse.

b) Means are to be provided to stop any running thruster at each of the steering stations.

c) A thruster angle indicator is to be provided at each steering station. The angle indicator is to be independent of the control system.

2.4.2 Alarm and monitoring equipment

Tab 4 summarises the minimum alarm and monitoring requirements for propulsion and steering thrusters; see also Sec 10, [4].

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	Slowdown	Shutdown	Control	Standby Start	Stop
Steering oil pressure	L						
Oil tank level	L						

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 5, [5.2] or Sec 6, [4.1] or Sec 7, [4.1].

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

a) Thrusters as per [1.1.1] admitted to an alternative scheme:

   for Manufacturers admitted to alternative inspection the requested certificates are specified in the agreed scheme.

b) Thrusters as per [1.1.1] not admitted to an alternative scheme:

   Tasneef certificates (C) (see Pt D, Ch 1, Sec 1, [4.2.1]) are required for material tests indicated in [3.1.1], and for works trials as per [3.2].

3.3.2 Mass produced thrusters

Mass produced thrusters may be accepted within the framework of the Tasneef type approval program.

3.4 Type approved thruster

3.4.1 Issue of Tasneef Type Approval Certificate *(1/1/2019)*

For yachts less than 500 GT, when ✠ **MACH** class notation is to be assigned, the thrusters defined in [1.1.1] as an alternative may be type approved by Tasneef

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 Tasneef

SECTION 12 TURBOCHARGERS

1 General

1.1 Application

1.1.1 These Rules apply to turbochargers fitted on diesel engines (main propulsion and auxiliary engines) of yachts for which the ✠ **MACH** notation is required and having a power of 1000 kW and above.

1.1.2 Turbochargers not included in [1.1.1] are to be designed and constructed according to sound marine practice and delivered with the works' certificate (W) relevant to the bench running test as per [2.2.3] and the hydrostatic test as per [2.2.4].

1.1.3 In the case of special types of turbochargers, Tasneef reserves the right to modify the requirements of this Section, demand additional requirements in individual cases and require that additional plans and data are submitted.

1.2 Documentation to be submitted

1.2.1 The Manufacturer is to submit to Tasneef the documents listed in Tab 1.

2 Material tests, workshop inspection and testing, certification

2.1 Material tests

2.1.1 Material tests (mechanical properties and chemical composition) are required for shafts and rotors, including blades (see [2.3.1] as regards the certificate required).

2.2 Workshop inspections and testing

2.2.1 Overspeed test

All wheels (impellers and inducers), when machine-finished and complete with all fittings and blades, are to undergo an overspeed test for at least 3 minutes at one of the following test speeds:

a) 20% above the maximum speed at room temperature

b) 10% above the maximum speed at the maximum working temperature.

Note 1: If each forged wheel is individually checked by an approved non-destructive examination method, no overspeed test is required.

2.2.2 Balancing

Each shaft and bladed wheel, as well as the complete rotating assembly, is to be dynamically balanced by means of equipment which is sufficiently sensitive in relation to the size of the rotating part to be balanced.

2.2.3 Bench running test

Each turbocharger is to undergo a mechanical running test at the bench for 20 minutes at maximum rotational speed at room temperature.

Subject to the agreement of Tasneef the duration of the running test may be reduced to 10 minutes, provided that the Manufacturer is able to verify the distribution of defects found during the running tests on the basis of a sufficient number of tested turbochargers.

For Manufacturers who have facilities in their works for testing turbochargers on an engine for which they are intended, the bench test may be replaced by a test run of 20 minutes at overload (110% of the maximum continuous output) on such engine.

Where turbochargers are admitted to an alternative inspection scheme and subject to the satisfactory findings of a historical audit, Tasneef may accept a bench test carried out on a sample basis.

2.2.4 Hydrostatic tests

The cooling spaces of turbochargers are to be hydrostatically tested at a test pressure of 0,4 MPa or 1,5 times the maximum working pressure, whichever is the greater.

2.3 Certification

2.3.1 Testing certification

a) Turbochargers admitted to an alternative inspection scheme:

   For Manufacturers admitted to alternative inspection the requested certificates are specified in the agreed scheme.

b) Turbochargers as per [1.1.1] not admitted to an alternative inspection scheme:

   Tasneef certificates (C) (see Pt D, Ch 1, Sec 1, [4.2.1]) are required for the bench running test as per [2.2.3] and the overspeed test as per [2.2.1], as well as for material and hydrostatic tests as per [2.2.4].

   Works' certificates (W) (see Pt D, Ch 1, Sec 1, [4.2.3]) are requested for material tests.

Table 1 : Documentation to be submitted

No	I/A (1)	Document
1	I	Technical specification of the turbocharger including the maximum operating conditions (maximum permissible rotational speed and maximum permissible temperature)
2	I	Operation and service manual
(1) A = to be submitted for approval in four copies; I = to be submitted for information in duplicate.		

2.4 Type approved turbocharger

2.4.1 Issue of Tasneef Type Approval Certificate

For yachts less than 500 GT, when ✠ **MACH** class notation is to be assigned, the turbocharger defined in [1.1.1] may be type approved by Tasneef

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].

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.

2.4.2 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 Tasneef

SECTION 13 REFRIGERATING INSTALLATIONS

1 General

1.1 Application

1.1.1 Refrigerating installations on all yachts *(1/1/2023)*

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 Tasneef

2 Minimum design requirements

2.1 Refrigerating installation components

2.1.1 General *(1/1/2023)*

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 *(1/1/2023)*

a) Pressure vessels of refrigerating plants are to comply with the relevant requirements of Sec 3.

b) Vessels intended to contain ammonia or toxic substances are to be considered as class 1 pressure vessels as indicated in Sec 3, [1.4].

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 *(1/1/2023)*

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 9, 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 yacht'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 Tasneef 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 Tasneef on a case by case basis.

2.2 Refrigerants

2.2.1 Prohibited refrigerants *(1/1/2023)*

The use of the following refrigerants is not allowed for shipboard installations:

- Methyl chloride
- R11 - Trichloromonofluoromethane (C Cl3 F)
- Ethane
- Ethylene
- Other substances with lower explosion limit in air of less than 3,5%.

2.2.2 Statutory requirements *(1/1/2023)*

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 *(1/1/2023)*

The arrangement of refrigerating machinery spaces of plants using toxic or flammable refrigerants will be the subject of special consideration by Tasneef

For specific requirements on spaces intended for plants using ammonia as a refrigerant see Pt C, Ch 1, Sec 13, [2.3] of the Rules for Ships and for those using carbon dioxide see Pt C, Ch 1, Sec 13, [2.4] of the Rules for Ships.

SECTION 14 TESTS ON BOARD

1 General

1.1 Application

1.1.1 This Section covers shipboard 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 shipboard 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.

2 General requirements for shipboard 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

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, Tasneef 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) detection of dangerous vibrations by taking the necessary readings when required

c) checks either deemed necessary for yacht classification or requested by the Interested Parties and which are possible only in the course of navigation in open sea.

3 Shipboard tests for machinery

3.1 Conditions of sea trials

3.1.1 Displacement of the yacht

Except in cases of practical impossibility, or in other cases to be considered individually, the sea trials are to be carried out at a condition as close as possible to the normal condition.

3.1.2 Performance of the machinery

The performance of the propulsion machinery in the course of the sea trials is to be as close as possible to the rated power.

3.2 Navigation and manoeuvring tests

3.2.1 Speed trials

Where required by the Interested Party, the speed of the yacht is to be determined using procedures deemed suitable by Tasneef by the average of the speeds taken in not less than two pairs of runs in opposite directions.

3.2.2 Astern trials

The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, and so to bring the yacht to rest within reasonable distance from maximum ahead service speed, is to be demonstrated.

3.3 Tests of diesel engines

3.3.1 Main propulsion engines driving fixed propellers

Sea trials of main propulsion engines driving fixed propellers are to include the following tests:

a) operation at rated engine speed n_0 for at least 1 hour

b) operation at minimum load speed

c) starting and reversing manoeuvres

d) tests of the monitoring, alarm and safety systems

Note 1: The tests in d) may be performed during the dock or sea trials.

3.3.2 Main propulsion engines driving controllable pitch propellers or reversing gears

a) The scope of the sea trials for main propulsion engines driving controllable pitch propellers or reversing gears is to comply with the relevant provisions of [3.3.1].

b) Engines driving controllable pitch propellers are to be tested at various propeller pitches.

3.3.3 Engines driving generators for propulsion

Sea trials of engines driving generators for propulsion are to include the following tests:

a) operation at 100% power (rated power) for at least 1 hour

b) starting manoeuvres

c) tests of the monitoring, alarm and safety systems.

Note 1: The above tests a) to c) are to be performed at rated speed with a constant governor setting. The power refers to the rated electrical power of the driven generators.

3.3.4 Engines driving auxiliaries

Engines driving generators or important auxiliaries are to be subjected to an operational test, it is to be demonstrated that the engine is capable of supplying 100% of its rated power and, in the case of shipboard generating sets, account is to be taken of the time needed to actuate the generator's overload protection system.

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 1 hour
- yacht 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 1/2 hour at their 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 electric propulsion system, power management and load limitation.

b) A test of the propulsion plant at 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.

This test program is to include at least:

- Speed rate of rise
- Endurance test:
    - 1 hour at 100% rated output power
    - 10 minutes at maximum astern running power
- 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
- Test of functionality of electric propulsion, when manoeuvring and during the yacht turning test
- Tst of power management performance: reduction of power due to loss of one or several generators to check the power limitation and propulsion availability in each case.

3.6 Tests of main propulsion shafting and propellers

3.6.1 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 yacht:
    - check of the engine (or gearbox) flanged coupling parameters (gap and sag)
    - check of the crankshaft deflections if required by the engine Manufacturer 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

3.6.2 Shafting vibrations

Torsional, bending and axial vibration measurements are to be carried out where required by Sec 8. The type of the measuring equipment and the location of the measurement points are to be specified.

3.6.3 Bearings *(1/1/2017)*

Except for external water lubricated bearings the temperature of the bearings is to be checked under the machinery power conditions specified in [3.1.2].

3.6.4 Sterntube sealing gland

The sterntube seal system is to be checked for possible leakage through the sterntube sealing gland.

3.6.5 Propellers

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.

3.7 Tests of piping systems

3.7.1 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 Tests of steering gear

3.8.1 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 10 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.

3.8.2 Tests to be performed

Tests of the steering gear are to include at least:

a) functional test of the main and auxiliary emergency steering gear with demonstration of the performances required by Sec 10, [2].

b) test of the steering gear power units, including transfer between steering gear power units

c) test of the means of communication between the navigation bridge, engine room and steering gear compartment

d) test of the alarms and indicators.

APPENDIX 1 PLASTIC PIPES

1 General

1.1 Application

1.1.1 These requirements are applicable to all piping systems with parts made of rigid plastic.

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].

1.2 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.

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 Tasneef 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.

c) The collapse pressure is not to be less than 0,3 MPa.

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.

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 Res. A.753(18) where "L1" is indicated in Tab 1
- a 30 min fire endurance test in dry conditions is to be carried out according to Appendix 1 of IMO Res. A.753(18) where "L2" is indicated in Tab 1
- a 30 min fire endurance test in wet conditions is to be carried out according to Appendix 2 of IMO Res. A.753(18) where "L3" is indicated 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".

2.3.2 Flame spread

a) All pipes, except those fitted on open decks and within tanks, cofferdams, pipe tunnels and ducts, are to have low spread characteristics not exceeding average values listed in IMO Resolution A.653(16).

b) Surface flame characteristics are to be determined using the procedure given in IMO Res. A.653(16) with regard to the modifications due to the curvilinear pipe surfaces as listed in Appendix 3 of Res. A.753(18).

c) Surface flame spread characteristics may also be determined using the test procedures given in ASTM D635, or other national equivalent standards.

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:

1×10^5 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 Tasneef for approval, prior to commencing the work.

Table 1 : Fire endurance of piping systems *(1/7/2021)*

PIPING SYSTEM	LOCATION						
	Machinery spaces of category A **(4)**	Other machinery spaces **(5)**	Fuel oil tanks	Ballast water tanks	Cofferdams, void spaces, pipe tunnels and ducts **(6)**	Accommodation, service and control spaces **(7)**	Open decks **(8)**
FLAMMABLE LIQUIDS (FLASHPOINT > 60°C)							
Fuel oil	X	X	0	0	0	L1 **(9)**	L1 **(9)**
Lubricating oil	X	X	NA	NA	0	L1 **(9)**	L1 **(9)**
Hydraulic oil	X	X	0	0	0	L1 **(9)**	L1 **(9)**
SEA WATER **(10)**							
Bilge main and branches	L1	L1	0	0	0	L1 **(9)**	L1
Fire main and water spray	L1	L1	NA	0	0	X	L1
Foam system	L1	L1	NA	NA	0	L1	L1
Sprinkler system	L1	L1	NA	0	0	L3	L3
Ballast	L3	L3	0	0	0	L2	L2
Cooling water, essential services	L3	L3	NA	0	0	L2	L2
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)	L1 **(2)**	L1 **(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

PIPING SYSTEM	LOCATION						
	Machinery spaces of category A **(4)**	Other machinery spaces **(5)**	Fuel oil tanks	Ballast water tanks	Cofferdams, void spaces, pipe tunnels and ducts **(6)**	Accommodation, service and control spaces **(7)**	Open decks **(8)**
SOUNDING, AIR							
Water tanks, dry spaces	0	0	0	0	0	0	0
Oil tanks (flash-point > 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

(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.
(2) For drains serving only the space concerned, “0” may replace “L1”.
(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 and cargo pump rooms, containing propulsion machinery, boilers, steam 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) Accommodation spaces, service spaces and control stations are defined in Ch 4, Sec 1, [1].
(8) Open decks are defined in Ch 4, Sec 1, [1].
(9) For yachts less than 500 GT, L1 may be replaced by L2.
(10) Pipes fitted below the heaviest water level, and connected to sea inlet and overboard discharge are to be metallic structural pipes.

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 shipboard 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 ship'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 x 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" (IMO Resolution A754 (18) as amended).

3.6.2 *(1/7/2021)*

When plastic pipes pass through watertight bulkheads or decks, the watertight integrity of the bulkhead or deck is to be maintained. providing metallic shut-off valve operable from above the freeboard deck 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

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 ship 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)** and **(3)**.

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 Tasneef for the intended use according to the Rules for Type Approval of Plastic Pipes. For yachts less than 500 GT, plastic piping that is not type approved may also be accepted provided that it is in conformity with a standard recognised by Tasneef

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.

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 If the Manufacturer does not have an approved quality system complying with ISO 9000 series standards or equivalent, pipes and fittings are to be tested in accordance with these requirements to the Surveyor's satisfaction for every batch of pipes.

4.3 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.

Part C

Machinery, Electrical Installations, Automation and Fire Protection

Chapter 2

ELECTRICAL INSTALLATIONS

SECTION 1	GENERAL
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APPENDIX 2	BATTERY POWERED YACHTS

SECTION 1 GENERAL

1 Application

1.1 General

1.1.1 *(1/1/2023)*
The requirements of this Chapter apply to electrical installations on yachts which have a gross tonnage less than 500. In particular, they apply to the components of electrical installations for:

- services essential to the propulsion, steering and safety of the yacht and
- services for habitability.

Note 1: Yachts of less than 500 GT which have length more than 50m will be considered on a case-by-case basis

1.1.2 The other parts of the installation are to be so designed as not to introduce any risks to persons on board or malfunctions to the above-mentioned services or to the yacht.

1.1.3 *(1/1/2023)*
For yachts which have a gross tonnage equal to or greater than 500, Part C, Ch 2 of Tasneef Rules for the Classification of Ships applies.

1.2 Exception

1.2.1 *(1/1/2020)*
The following requirements do not apply to yachts which are to comply with Part C, Chapter 2 of Tasneef Rules for the Classification of Ships:

- 30 minute recovery time limit from blackout/dead ship condition as per Pt C, Ch 2, Sec 3 [2.3.8].

1.3 References to other regulations and standards

1.3.1 Tasneef may refer to other regulations and standards when deemed necessary. These include the IEC publications, notably the IEC 60092 series and ISO standards.

1.3.2 When referred to by Tasneef publications by the International Electrotechnical Commission (IEC) or other internationally recognised standards are those currently in force at the date of agreement for yacht classification.

2 Documentation to be submitted

2.1 General

2.1.1 The documents listed in [2.1.2] 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.

Tasneef 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 Tasneef documents for approval are to be sent in triplicate if submitted by the shipyard and in four copies if submitted by the equipment supplier.

Documents requested for information are to be sent in triplicate.

In any case, Tasneef reserves the right to require additional copies when deemed necessary.

2.1.2 *(1/1/2017)*
The documents indicated in Tab 1 are to be submitted for approval ("Calculation of short-circuit currents" is to be submitted for information only):

Table 1 : Documents to be submitted *(1/1/2016)*

	Title
1	Single line diagram of main and emergency power systems (including ac and dc power systems) and single line diagram of lighting systems
2	Electrical power balance of main and emergency supply (including transitional source of emergency power, when required)
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)
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
5	Single line diagram and detailed diagram functional of the main switchboard
6	Single line diagram and detailed diagram functional of the emergency switchboard
7	Diagram of the most important section boards and motor control centres above 100 A
8	Detailed diagram of the navigation-light switchboard
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.

2.1.3 *(1/1/2017)*

For the detail of the documents required for approval see App 1.

3 Definitions

3.1 General

3.1.1 Unless otherwise stated, the terms used in this Chapter have the definitions laid down by 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 yacht, and services to ensure minimum comfortable conditions of habitability.

3.3 Safety voltage

3.3.1 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.

3.3.2 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.

3.4 Low voltage systems

3.4.1 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.

3.5 High voltage systems

3.5.1 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.

3.6 Basic insulation

3.6.1 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.

3.7 Supplementary insulation

3.7.1 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.

3.8 Double insulation

3.8.1 Insulation comprising both basic insulation and supplementary insulation.

3.9 Reinforced insulation

3.9.1 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.

3.10 Earthing

3.10.1 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.

3.11 Normal operational and habitable condition

3.11.1 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.

3.12 Emergency condition

3.12.1 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.

3.13 Main source of electrical power

3.13.1 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.

3.14 Emergency source of electrical power

3.14.1 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.

3.15 Section boards

3.15.1 *(1/1/2017)*

A switchgear and controlgear assembly which is supplied by another assembly and arranged for the distribution of electrical energy to other section boards or distribution boards.

3.16 Distribution board

3.16.1 *(1/1/2017)*

A switchgear and controlgear assembly arranged for the distribution of electrical energy to final sub-circuits.

3.17 Final sub-circuit

3.17.1 That portion of a wiring system extending beyond the final required overcurrent protective device of a board.

3.18 Hazardous areas

3.18.1 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.

3.18.2

Hazardous areas are classified in zones based upon the frequency and the duration of the occurrence of an explosive atmosphere.

3.18.3

Hazardous areas for explosive gas atmospheres are classified in the following zones:

- Zone 0: an area in which an explosive gas atmosphere is present continuously or is present for long periods
- Zone 1: an area in which an explosive gas atmosphere is likely to occur under normal operations
- Zone 2: an area in which an explosive gas atmosphere is not likely to occur under normal operations and if it does occur, it is likely to do so only infrequently and will exist for a short period only.

3.19 Certified safe type equipment

3.19.1 Certified safe type equipment is electrical equipment of a type for which a national or other appropriate authority has carried out the type verification and tests necessary to certify the safety of the equipment with regard to explosion hazard when used in an explosive gas atmosphere.

3.20 Navigation Light

3.20.1 *(1/1/2016)*

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,
- all-round flashing yellow light required for air-cushion vessels by Rule 23 of COLREGs, manoeuvring light required by Rule 34(b) of COLREGs.

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.

1.2 Ambient air temperatures

1.2.1 For yachts classed for unrestricted navigation, the ambient air temperature ranges shown in Tab 1 are applicable in relation to the various locations of installation.

1.2.2 For yachts classed for service in specific zones, Tasneef may accept different ranges for the ambient air temperature (e.g. for yachts 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

Location	Temperature range °C	
Enclosed spaces	+ 5	+ 45
Inside consoles or fitted on combustion engines and similar	+ 5	+ 55
Air-conditioned areas	+ 5	+ 40
Exposed decks	- 25	+ 45

1.3 Cooling water temperatures

1.3.1 The temperatures shown in Tab 2 are applicable to yachts classed for unrestricted service.

1.3.2 For yachts classed for service in specific zones, Tasneef may accept different values for the cooling water temperature (e.g. for yachts operating outside the tropical belt, the maximum cooling water temperature may be assumed as equal to + 25 °C instead of + 32 °C).

Table 2 : Water temperature

Coolant	Temperature range °C	
Sea water	0	+ 32

1.4 Inclinations of yachts

1.4.1 Electrical equipment is to operate satisfactorily under normal conditions with the craft at the following inclinations from normal:

- for all craft:
  - rolling: up to ± 22,50°;
  - pitching: ± 7,50°; and
- for sailing craft only: at a constant heel ± 45°.

Note 1: In principle, electrical equipment should be capable of operating as designed with the vessel in the maximum expected heel and pitch during normal operation.

2 Quality of power supply

2.1 General

2.1.1 All electrical components are to be so designed and manufactured that they are capable of operating satisfactorily under the variations of voltage, frequency and harmonic distortion of the power supply specified in [2.2] and [2.3].

2.2 A.c. distribution systems

2.2.1 For alternating current components, the voltage and frequency variations of power supply shown in Tab 3 are to be assumed.

2.2.2 *(1/1/2016)*

Equipment shall function under the harmonic distortion which can occur in the distribution system in normal operation. The system shall be designed to operate within the following limits:

- single harmonic distortion: < 3%;
- total harmonic distortion: < 5%.

Higher values for the harmonic content (e.g. in electric propulsion plant system) may be accepted by Tasneef on the basis of correct operation of all electrical devices to be demonstrated during the sea trials.

Table 3 : Voltage and frequency variations of power supply in a.c.

Parameter	Variations		
	Continuous		Transient
Voltage	+ 6%	- 10%	± 20% (recovery time: 1,5 s)
Frequency	± 5%		± 10% (recovery time: 5 s)
Note 1: For alternating current components supplied by emergency generating sets, different variations may be considered.			

2.3 D.c. distribution systems

2.3.1 For direct current components, the voltage variations of power supply shown in Tab 4 are to be assumed.

Table 4 : Voltage variations of power supply in d.c.

Parameters	Variations
Voltage tolerance (continuous)	± 10%
Voltage cyclic variation	5%
Voltage ripple (a.c. r.m.s. over steady d.c. voltage)	10%

2.3.2 For direct current components supplied by an electrical battery the following voltage variations are to be assumed:

- +30% to -25% for components connected to the battery during charging (see Note 1)
- +20% to -25% for components not connected to the battery during charging.

Note 1: Different voltage variations as determined by the charging/discharging characteristics, including ripple voltage from the charging device, may be considered.

3 Materials

3.1 General

3.1.1 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.

3.1.2 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 Construction

4.1 General

4.1.1 All electrical apparatus is to be so constructed as not to cause injury when handled or touched in the normal manner.

4.1.2 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.

4.1.3 Enclosures are to be of adequate mechanical strength and rigidity.

4.1.4 Cable entrances are not to impair the degree of protection of the relevant enclosure (see Sec 3, Tab 2).

4.1.5 All nuts and screws used in connection with current carrying parts and working parts are to be effectively locked.

4.1.6 All equipment is generally to be provided with suitable, fixed terminal connectors in an accessible position for convenient connection of the external cables.

4.2 Degree of protection of enclosures

4.2.1 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.

4.2.2 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.

4.3 Protection against explosive gas or vapour atmosphere hazard

4.3.1 Electrical equipment intended for use in areas where explosive gas or vapour atmospheres may occur is to be of a "certified safe type" suitable for the relevant flammable atmosphere and for shipboard use.

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. three-phase four-wire insulated) will be considered by Tasneef 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 the use, under conditions approved by Tasneef 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.

1.2 Maximum voltages

1.2.1 The maximum voltages for both alternating current and direct current low voltage systems of supply for the craft's services are given in Tab 1.

1.2.2 Voltages exceeding those shown will be specially considered in the case of specific systems.

Table 1 : Maximum voltages

Use		Maximum voltage V
For apparatus 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 apparatus 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.

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 *(1/1/2016)*

The yacht's electrical power may be supplied by generator(s) and/or main batteries having sufficient capacity to supply the essential services.

2.2.2 *(1/1/2016)*

The main source of electrical power is to consist of at least two generating sets or two accumulator batteries with the associated DC generator(s) capable of charging the main batteries to 80% charge within 10 h and simultaneously supplying the essential services, or a combination of these sources of power.

2.2.3 *(1/1/2016)*

Where the electrical power is necessary for the main propulsion and/or steering of the yacht, 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) normal operational conditions of propulsion and safety

b) minimum comfortable conditions of habitability.

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.

The services necessary to provide normal operational conditions of propulsion and safety ì and minimum confortable conditions of habitability do not include:

- thrusters not forming part of the main propulsion
- refrigerators for air conditioning.

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.

2.2.4 The arrangement of the craft's source of electrical power is to be such that essential services can be maintained regardless of the speed and direction of rotation of the main propulsion machinery or shafting.

2.2.5 *(1/1/2016)*

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 craft's source of electrical power if, in all sailing and manoeuvring conditions including the propeller being stopped, their capacity is sufficient to provide the electrical power to the essential services.

2.2.6 They are to be not less effective and reliable than the independent generating sets.

2.3 Emergency source of electrical power and emergency installations

2.3.1 A self-contained emergency source of electrical power is to be provided.

2.3.2 The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously.

2.3.3 *(1/1/2016)*

The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously for 6 hours at least, if they depend upon an electrical source for their operation:

- the craft's emergency lights to assist escape from all enclosed spaces and to illuminate the disembarkation position and the craft's navigation station,
- the internal signals and communication equipment as required in an emergency,
- the navigation lights
- the VHF or SSB radio installation and navigational equipment,
- the fire detection and fire alarm system
- other emergency services (e.g. bilge and fire pumps).

Note 1: in yachts only enabled to voyages of short duration like those having navigation notation "special navigation" where the route is not greater than 20 nautical miles offshore, Tasneef may accept a reduced period of time, but not less than three hours.

2.3.4 *(1/1/2016)*

The transitional source of emergency electrical power, where required by [2.3.9], is to consist of an accumulator battery and is to be so arranged as to supply automatically, in the event of failure of either the main or the emergency source of electrical power, for half an hour at least the services stated in [2.3.3].

2.3.5 *(1/1/2016)*

A visual and audible indicator is to be mounted in a normally attended location to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power are being discharged.

2.3.6 Provision is to be made for the periodical testing of the complete emergency system and is to include the testing of automatic starting arrangements of the emergency generator, where fitted.

2.3.7 For starting arrangements of emergency generating sets, see Ch 1, Sec 2, [3.1].

2.3.8 The emergency source of electrical power may be either a generator or an accumulator battery.

2.3.9 *(1/1/2016)*

Where the emergency source of electrical power is a generator, it is to 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 electrical power supply to the emergency switchboard from the main source of electrical power 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 such that those services referred to in [2.3.3] are powered.
c) provided with a transitional source of emergency electrical power according to [2.3.4] 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.

2.3.10 Where the emergency source of electrical power is an accumulator battery, it is to 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 [2.3.3].

2.4 Measuring instruments

2.4.1 *(1/1/2016)*

Wattmeters for use with a.c. generators which may be operated in parallel are to be capable of indicating 15% reverse power.

2.4.2 *(1/1/2016)*

For wattmeters using one current circuit only, the measurement of the current of all generators is to be made in the same phase.

2.4.3 *(1/1/2016)*

Normal full load values is to be marked in red on the instrument scale for all indicating instruments and appropriate labels are to be fixed to digital instruments when employed.

2.4.4 *(1/1/2016)*

The secondary windings of instrument transformers are to be earthed.

2.4.5 *(1/1/2016)*

Each d.c. generator with an output of 2 kW or more, not operated in parallel, is to be provided with at least:

- 1 voltmeter
- 1 ammeter.

2.4.6 *(1/1/2016)*

Each a.c. generator, except single-phase generators smaller than 2 kVA, not operated in parallel is to be provided with:

- 1 voltmeter
- 1 frequency meter for generators greater than 15 kVA
- 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.

2.4.7 *(1/1/2016)*

Each d.c. generator operated in parallel is to be provided with:

- 1 voltmeter for each generator or one voltmeter and a changeover for its connection to each generator,
- 1 ammeter for each generator.

2.4.8 *(1/1/2016)*

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.

2.4.9 *(1/1/2016)*

For paralleling purposes the following are to be provided:

- 2 voltmeters
- 2 frequency meters
- 1 synchroscope and synchronising indicating lamps or equivalent means.

2.4.10 *(1/1/2016)*

Each secondary distribution system is to be provided with one voltmeter.

2.4.11 *(1/1/2016)*

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)

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 is to be made (e.g. d.c./d.c. converters or transformers) such that current unbalances do not occur in the individual poles or phases.

3.2 Insulated distribution systems

3.2.1 Every insulated distribution system, whether primary or secondary, for power, heating or lighting is to 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.

3.2.2 For safety voltage systems, alternative devices (i. e: lamps) may be accepted.

3.3 Distribution of electrical power

3.3.1 Where the main source of electrical power is necessary for propulsion 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.

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 section boards.

3.3.2 *(1/1/2016)*

A main electric lighting system which is to provide illumination throughout those parts of the yacht that are normally accessible to and used by personnel or passengers is to be supplied from the main source of electrical power.

3.4 Emergency distribution of electrical power

3.4.1 *(1/1/2016)*

The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be adequately protected at the main switchboard against overload and short-circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power.

Where the system is arranged for feedback operation (the main switchboard may be supplied by the emergency switchboard), the interconnector feeder is also to be protected at the emergency switchboard at least against short-circuit.

3.5 Shore supply

3.5.1 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.

3.5.2 Permanently fixed cables of adequate rating are to be provided for connecting the box to the main switchboard.

3.5.3 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.

3.5.4 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 switchboard.

3.5.5 Means are to be provided for checking the phase sequence of the incoming supply in relation to the yacht's system.

3.5.6 The cable connection to the box is to be provided with at least one switch-disconnector on the main switchboard.

3.5.7 The shore connection is to be provided with an indicator at the main switchboard in order to show when the cable is energised.

3.5.8 At the connection box a notice is to be provided giving full information on the nominal voltage and frequency of the installation.

3.5.9 The switch-disconnector on the main switchboard is to be interlocked with the generator circuit-breakers in order to prevent its closure when any generator is supplying the main switchboard unless special provision is made to the satisfaction of Tasneef to permit safe transfer of electrical load

3.5.10 Adequate means are to be provided to equalise the potential between the hull and the shore when the electrical installation of the yacht is supplied from shore.

3.6 Supply of motors

3.6.1 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).

3.6.2 Each motor is to be provided with control gear 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.

3.6.3 Efficient means are to be provided for the isolation of the motor and its associated control gear from all live poles of the supply.

3.7 Power supply to heaters

3.7.1 Each heater rated more than 16A is to be connected to a separate final circuit.

3.8 Power supply to lighting installations

3.8.1 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.

3.9 Navigation lights

3.9.1 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.

3.9.2 *(1/1/2016)*

The navigation light distribution board is to be supplied from two alternative circuits, one from the craft's main source of power and one from the emergency source of power.

The transfer of supply is to be practicable from the bridge, for example by means of a switch.

3.9.3 *(1/1/2016)*

Each navigation light is to be controlled and protected by a double-pole switch and a fuse in each insulated pole or, alternatively, by a double-pole circuit-breaker, fitted on the distribution board referred to in [3.9.1].

3.9.4 *(1/1/2016)*

Where it is not possible to visually observe the operation of the navigation lights from the yacht's decks, such lights are to be provided with an automatic indicator giving individual audible or visual warning in the event of failure of a navigation light.

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.

3.10 Control and indication circuits

3.10.1 *(1/1/2016)*

Control and indicating circuits relative to essential services that are to be in continuous operation to maintain propulsion and steering are to be branched off from the main circuit in which the relevant equipment is installed. Equivalent arrangements may be accepted by Tasneef

3.10.2 *(1/1/2016)*

Control and indicating circuits relative to essential services necessary to maintain the yacht's safety may be supplied by distribution systems reserved for the purpose to the satisfaction of Tasneef

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 item, equipment installed in spaces with an explosion hazard is also subject to the provisions of Sec 2, [4.3].

4.2 Cable entry

4.2.1 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.

Table 2 : Degrees of protection *(1/1/2016)*

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.								

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 Tasneef such as that given in IEC Publication 60363.

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 *(1/1/2016)*

Circuit-breakers are to be suitable for isolation or of with drawable type 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 *(1/1/2016)*

In the selection of circuit-breakers with intentional short-time delay for short-circuit release, 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, utilisation categories A and B are defined 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 oa short-time withstand current rating (I_{cw}).
- 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 (I_{cw}).

6.3.4 For duplicated essential services and non-essential services, circuit-breakers may be selected according to their ultimate short-circuit breaking capacity (Icu).

6.3.5 *(1/1/2016)*

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 *(1/1/2016)*

For fuse-switch disconnectors 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 backup 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 backup 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 backup 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 backedup circuit-breaker is located away from the back-up breaker or fuse.

6.4.10 The protection of circuits is to be such that a fault in one service does not cause the loss of any essential services.

6.4.11 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.

6.5 Protection against overload

6.5.1 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.

6.5.2 The use of fuses up to 320 A for overload protection is permitted.

6.6 Localisation of overcurrent protection

6.6.1 Short-circuit protection is to be provided for every non-earthed conductor.

6.6.2 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.

6.6.3 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.

6.6.4 Electrical protection is to be located as close as possible to the origin of the protected circuit.

6.7 Protection of generators

6.7.1 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.

6.7.2 When multipole switch and fuses are used, the fuse rating is to be maximum 110% of the generator rated current.

6.7.3 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.

6.7.4 For emergency generators the overload protection may, instead of disconnecting the generator automatically, give a visual and audible alarm in a permanently attended space.

6.7.5 After disconnection of a generator due to overload, the circuit-breaker is to be ready for immediate reclosure.

6.7.6 Generator circuit-breakers are to be provided with a reclosing inhibitor which prevents their automatic reclosure after tripping due to a short-circuit.

6.7.7 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.

6.7.8 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 reverse-power protection may be replaced by other devices ensuring adequate protection of the prime mover.

6.7.9 Generators are to be provided with 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 from 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.

6.8 Protection of circuits

6.8.1 *(1/1/2016)*

Each separate circuit, other than engine starting and ignition circuits, is to be protected against short-circuit and overload by a multipole circuit-breaker or switch and fuses.

6.8.2 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.

6.8.3 The protective devices of the circuits supplying motors are to allow excess current to pass during transient starting of motors.

6.8.4 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.

6.8.5 Steering gear circuits are to be provided with short-circuit protection only.

6.9 Protection of motors

6.9.1 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.

6.9.2 For motors intended for essential services, the overload protection may be replaced by an overload alarm (for steering gear motors see Ch 1, Sec 10 [2.4]).

6.9.3

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.

6.9.4 For continuous duty motors the protective gear is to have a time delay characteristic which ensures reliable thermal protection against overload.

6.9.5 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.

6.9.6 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.

6.9.7 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.

6.9.8 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.

6.9.9 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.

6.9.10 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.

6.10 Protection of storage batteries

6.10.1 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.

6.10.2 Emergency batteries supplying essential services are to have short-circuit protection only.

6.11 Protection of shore power connection

6.11.1 Permanently fixed cables connecting the shore connection box to the main switchboard are to be protected by fuses or circuit-breakers (see [3.5.4]).

6.12 Protection of measuring instruments, pilot lamps and control circuits

6.12.1 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.

6.12.2 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.

6.12.3 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.

6.12.4 Circuits whose failure could endanger operation, such as steering gear control feeder circuits, are to be protected only against short-circuit.

6.12.5 The protection is to be adequate for the minimum cross-section of the protected circuits.

6.13 Protection of transformers

6.13.1 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.

6.13.2 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.

6.13.3 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 *(1/1/2016)*

Cables are to be manufactured in accordance with the relevant recommendations of IEC Publications 60092-350, 60092-352, 60092-353, 60092-354 and 60092-376 or in accordance with other equivalent international or national marine standards recognized by Tasneef (e.g. Standards CEI 18-.. series).

8.1.2 *(1/1/2016)*

All electrical cables and wiring external to equipment are to be at least of a flame-retardant type, in accordance with IEC Publication 60332-1-1 and IEC 60332-1-2.

8.1.3 *(1/1/2016)*

In addition to the provisions of [8.1.2], when cables are laid in bundles, cable types are to be chosen in compliance with IEC Publication 60332-3-22 category A, or other means are to be provided such as not to impair their original flame-retarding properties.

8.1.4 Where necessary for specific applications such as radio frequency or digital communication systems, which require the use of particular types of cables, Tasneef may permit the use of cables which do not comply with the provisions of [8.1.2] and [8.1.3].

8.1.5 *(1/1/2016)*

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 independent 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].

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 shipboard 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.

Table 3 : Maximum rated conductor temperature

Type of insulating compound	Abbreviated designation	Maximum rated conductor temperature °C	
		Normal operation	Short-circuit
a) Thermoplastic:			
- based upon polyvinyl chloride or copolymer of vinyl chloride and vinyl acetate	PVC/A	60	150
b) Elastomeric or thermosetting:			
- based on ethylene-propylene rubber or similar (EPM or EPDM)	EPR	85	250
- based on high modulus or hardgrade ethylene propylene rubber	HEPR	85	250
- based on cross-linked polyethylene	XLPE	85	250
- based on rubber silicon	S 95	95	350
- based on ethylene-propylene rubber or similar (EPM or EPDM) halogen free	HF EPR	85	250
- based on high modulus or hardgrade halogen free ethylene propylene rubber	HF HEPR	85	250
- based on cross-linked polyethylene halogen free	HF XLPE	85	250
- based on rubber silicon halogen free	HF S 95	95	350
- based on cross-linked polyolefin material for halogen free cable **(1)**	HF 85	85	250
(1) Used on sheathed cable only			

8.3 Choice of protective covering

8.3.1 Cables fitted on decks exposed to the weather, in damp and wet locations (e.g. bathrooms), in refrigerated spaces, in machinery spaces and wherever water condensation or harmful vapours (including oil vapour) may be present are to have an impervious sheath.

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.

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 Some cable sheaths (such as PVC) may react chemically in contact with polyurethane foam. The risk is to be avoided by suitable choice of cable, mechanical protection or other appropriate installation method.

8.3.6 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 [9].

8.6 Electrical services required to be operable under fire conditions and fire-resistant cables

8.6.1 *(1/1/2016)*

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
- Public address systems
- Remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and/or explosion.

8.6.2 *(1/1/2016)*

Where cables for services specified in [8.6.1] 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 crossed 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 1.

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 self-monitoring, fail-safe or duplicated with cable runs as widely separated as is practicable may be exempted.

Note 1:

- For the purpose of application of this item [8.6], the definition of "high fire risk areas" is the following:
  - Machinery spaces as defined in Chapter 4, Sec1
  - Spaces containing fuel treatment equipment and other highly flammable substances
  - Galleys and pantries containing cooking appliances
  - Laundry containing drying equipment
- Fire-resistant type cables are to be easily distinguishable
- For special cables, requirements in the following standards may be used:
  - IEC60331-23: Procedures and requirements - Electrical data cables
  - IEC60331-25: Procedures and requirements - Optical fibre cables.

8.6.3 *(1/1/2016)*

The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps or 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 Internal wiring of switchboards and other enclosures for equipment

8.7.1

For installation in switchboards and other enclosures for equipment (up to a rated voltage of 440 V), single-core cables may be used without further protection (sheath). Other types of flame-retardant switchboard wiring may be accepted at the discretion of Tasneef

8.8 Current carrying capacity of cables

8.8.1 The current carrying capacity for continuous service of cables is given in Tab 4.

8.8.2 The current carrying capacity cited in [8.7.1] is applicable, with rough approximation, to all types of protective covering (e.g. both armoured and non-armoured cables).

8.8.3 Values other than those shown in Tab 4 may be accepted provided they are determined on the basis of calculation methods or experimental values approved by Tasneef

8.8.4 When the actual ambient temperature obviously differs from 45°C, the correction factors shown in Tab 6 may be applied to the current carrying capacity in Tab 4.

8.8.5 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.

8.8.6 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 may be increased by applying the corresponding correction factors given in Tab 7. In no case is a period shorter than half an hour to be used, whatever the effective period of operation.

8.8.7 For supply cables to single services for intermittent loads (e.g. cargo winches or machinery space cranes), the current carrying capacity obtained from Tab 4 may be increased by applying the correction factors given in Tab 8. 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.

Table 4 : Current rating for single-core cables in continuous service (ambient temperature 45 °C)

1	2	3	4	5	6
Nominal cross-sectional area of conductors S	Cable insulation				
	General purpose PVC	Heat resistant PVC	Butly rubber	EPR and XLPE	Silicone rubber and mineral insulation
	Maximum permissible service temperature of the conductor				
	60 °C	75 °C	80 °C	85 °C	95 °C
mm²	A	A	A	A	A
1	8	13	15	16	20
1,5	12	17	19	20	24
2.5	17	24	26	28	32
4	22	32	35	38	42
6	29	41	45	48	55
10	40	57	63	67	75
16	54	76	84	90	100
25	71	100	110	120	135
35	87	125	140	145	165
50	105	150	165	180	200

Note 1: The current rating, I, in amperes, has been calculated for each nominal cross-sectional area S in square millimetres, using the formula:

$I = \alpha \cdot S^{0,625}$

where α is a coefficient related to the maximum permessible service temperature of the conductor as indicated in Tab 5.

Note 2: When a mineral-insulated cable is installed in a location where its copper sheath is liable to be touched by hand when in service, the current rating shown in column 6 is to be multiplied by the correction factor 0.70 to ensure that the sheath temperature does not exceed 70 °C.

Table 5 : Value of α

Maximum permissible temperature of the conductor			60 °C	75 °C	80 °C	85 °C	95 °C
Value of α	For nominal cross-sectional area	$S \geq 2,5$ mm²	9,5	13,5	15	16	18
		$S < 2,5$ mm²	8	13	15	16	20

Table 6 : Correction factors for various ambient air temperatures

1	2	3	4	5	6	7	8	9	10	11	12
Maximum conductor temperature	Correction factors ambient air temperatures °C										
°C	35	40	45	50	55	60	65	70	75	80	85
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 7 : Correction factors for half-hour and one-hour service

1	2	3
Normal cross-sectional area mm²	Half-hour service	One-hour service
1 to 10	1,06	1,06
16	1,09	1,06
25	1,19	1,08
35	1,34	1,14
50	1,55	1,25

8.9 Minimum nominal cross-sectional area of conductors

8.9.1 In general the minimum allowable conductor cross-sectional areas are those given in Tab 9.

8.9.2 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 mm². In such case the cross-sectional area of the neutral conductor is to be equal to that of the phase.

8.9.3 For the nominal cross-sectional area of:

- earthing conductors, see Sec 5, [2.3]
- earthing connections for distribution systems, see Sec 5, [2.5]

Table 8 : Correction factors for intermittent service

Sun of nominal cross-sectional 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 ≤ 5	1,10
	5 < S ≤ 8	1,15
	8 < S ≤ 16	1,20
S ≤ 4	16 < S ≤ 825	1,25
4 < S ≤ 7	25 < S ≤ 42	1,30
7 < S ≤ 17	42 < S ≤ 72	1,35
17 < S ≤ 42	72 < S ≤ 140	1,40
42 < S ≤ 110	140 < S	1,45
110 < S	-	1,50

Table 9 : Minimum nominal cross-sectional areas

Service	Nominal cross-sectional area	
	external wiring mm²	internal wiring mm²
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 yacht or crew calls	0,2	0,1
Bus and data cables	0,2	0,1

8.10 Choice of cables

8.10.1 The rated voltage of any cable is to be not lower than the nominal voltage of the circuit for which it is used.

8.10.2 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.

8.10.3 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.

8.10.4 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 50 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.

8.11 Parallel connection of cables

8.11.1 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 Tasneef 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:
   - degree of protection of the enclosure
   - maximum surface temperature

b) risk of explosive gas atmosphere:
   - 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 to be located in a non-hazardous area.

Such switches and equipment located in hazardous areas are to be suitably labelled for identification purposes.

9.1.4 *(15/8/2017)*

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.

9.1.5 *(15/8/2017)*

For electrical equipment installed in Zone 1 hazardous areas, only the following types are permitted:

- any type that is permitted 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 *(15/8/2017)*

For electrical equipment installed in Zone 2 hazardous areas, only the following types are permitted:

- any type that is permitted 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
- of a type which ensures the absence of sparks and arcs (or of a minimum class of protection IP55) and the absence of "hot spots" during its normal operation.

9.1.7 *(15/8/2017)*

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 *(15/8/2017)*

Electrical equipment which is intended for use in explosive gas atmospheres or which is installed where flammable gases, vapours 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 *(15/8/2017)*

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 non-metallic impervious sheath in combination with braiding or other metallic covering
- a copper or stainless steel sheath (for mineral insulated cables only).

9.2.3 *(15/8/2017)*

All cables installed in Zone 2 areas are to be provided with at least a non-metallic external impervious sheath.

9.2.4 *(15/8/2017)*

Cables of intrinsically safe circuits are to have a metallic shielding with at least a non-metallic external impervious sheath.

9.2.5 *(15/8/2017)*

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 *(1/1/2016)*

Only intrinsically safe apparatus and certified safe type lighting fittings may be installed in compartments where large vented storage batteries are located (see Ch 2, Sec 4 [5.2.1]).

The associated switches are to be installed outside such spaces.

Electric ventilator motors are to be located 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.

9.3.2 Electrical equipment for use in battery rooms is to have minimum explosion group IIC and temperature class T1.

9.3.3 Standard marine electrical equipment may be installed in compartments assigned solely to valve-regulated sealed storage batteries.

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 *(15/8/2017)*

On 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 *(15/8/2017)*

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 *(15/8/2017)*

Electrical equipment and cables in exhaust ventilation ducts are to be as stated in [9.4.2].

10 Underwater lights

10.1 General

10.1.1 *(1/1/2016)*

The lights 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:

- IP68 for the external part
- IP67 for the internal part.

The lights 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.

10.1.2 *(1/1/2016)*

Where lights 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.

10.1.3 *(1/1/2016)*

Constructional drawings of the lights, including materials and characteristics of all components are to be submitted for examination.

10.1.4 *(1/1/2016)*

Underwater lights 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.

SECTION 4 LOCATION

1 General

1.1 Location

1.1.1 The degree of protection of the enclosures of the equipment is to be appropriate to the spaces or areas in which it is located (see Sec 3, Tab 2).

2 Emergency electrical system

2.1 Spaces for the emergency source

2.1.1 *(1/1/2016)*

The emergency source of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard is to be located above the uppermost continuous deck and shall be readily accessible from the open deck.

2.1.2 *(1/1/2016)*

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 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.

2.2 Emergency switchboard

2.2.1 The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

2.2.2 Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

2.3 Emergency battery

2.3.1 *(1/1/2016)*

In general, accumulator batteries fitted in accordance with the provisions of Sec 3, [2.3] are not to be located in the same space as the emergency switchboard.

2.3.2 *(1/1/2016)*

As an exception to 2.3.1, accumulator batteries fitted in accordance with the provisions of Sec 3, [2.3] and connected to a charging device of power of 2 kW or less may be accepted in the same space as the emergency switchboard but outside the emergency switchboard to the satisfaction of Tasneef

3 Distribution boards

3.1 Distribution board for navigation lights

3.1.1 The distribution board for navigation lights is to be placed in an accessible position on the bridge.

4 Cable runs

4.1 General

4.1.1 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.

4.1.2 Cable runs are to be selected so as to avoid action from condensed moisture and from dripping of liquids.

4.1.3 Connection and draw boxes are to be accessible.

4.1.4 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.

4.2 Location of cables in relation to the risk of fire and overheating

4.2.1 Cables and wiring serving essential or emergency power, lighting, internal communications or signals are, so far as is practicable, to be routed clear of high fire risk areas, (e.g. galley or machinery space of category A) except for supplying equipment in those spaces.

4.2.2 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, the cable is to be of a fire-resistant type or adequately protected against direct exposure to fire.

4.2.3 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, section 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.

4.2.4 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.

4.2.5 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.

4.3 Location of cables in relation to electromagnetic interference

4.3.1 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.

4.4 Services with a duplicate feeder

4.4.1 In the case of essential services requiring a duplicate supply, 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 Storage batteries

5.1 General

5.1.1 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.

5.1.2 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.

5.1.3 Starter batteries are to be located as close as practicable to the engine or engines served.

5.1.4 Accumulator batteries are not to be located in sleeping quarters except where hermetically sealed to the satisfaction of Tasneef

5.1.5 Lead-acid batteries and alkaline batteries are not to be installed in the same compartment (room, locker, box), unless of valve-regulated sealed type.

5.2 Large vented batteries

5.2.1 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. Otherwise, sealed batteries are to be installed.

5.2.2 Rooms assigned to large batteries are to be provided with mechanical exhaust ventilation. Natural ventilation may be employed for boxes located on open deck.

5.2.3 The provisions of [5.2.1] and [5.2.2] also apply to several batteries connected to charging devices of total power exceeding 2 kW calculated for each one as stated in [5.2.1].

5.3 Moderate vented batteries

5.3.1 Batteries connected to a charging device of power between 0,2 kW and 2 kW calculated as stated in [5.2.1] (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.

5.3.2 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.

5.3.3 The provisions of [5.3.1] and [5.3.2] 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 [5.2.1].

5.4 Small vented batteries

5.4.1 Batteries connected to a charging device of power less than 0,2 kW calculated as stated in [5.2.1] (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.

5.4.2 Boxes for small batteries may be ventilated only by means of openings near the top to permit escape of gas.

5.5 Ventilation

5.5.1 The ventilation of battery compartments is to be independent of ventilation systems for other spaces.

5.5.2 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.

5.5.3 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 [5.5.2].

5.5.4 Ducts are to be made of a corrosion-resisting material or their interior surfaces are to be painted with corrosion-resistant paint.

5.5.5 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).

5.5.6

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.

5.5.7 In mechanical exhaust ventilation systems:

a) electric motors are to be located 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.

5.5.8

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 5 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 and/or boiler rooms.

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.

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.

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>$\leq$ 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 $\leq$ 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>

2.3.4 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 yacht's structure

2.4.1 In case of yacht of 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.

Such earthing connection is not to be used for other purposes.

The connection is to be located in an accessible position where it may readily be checked.

2.4.2 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 m^2, 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 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 athwartship, 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 from 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 switch-board, 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 provided that access for operation is ensured.

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. 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 Section boards and distribution boards

6.3.1 For the installation of section and 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.

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.

7.3 Fixing of cables

7.3.1 Cables are to 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.

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 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.

7.4 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, 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.

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 yachts or collective tape screening	Any	8 D
Thermoplastic or thermosetting with shaped copper conductors	Any	Any	8 D

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 (intrinsically safe circuits, control circuits, 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, [8.4].

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, [9.2].

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.

8 Electrolytic corrosion

8.1 General

8.1.1 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 6 EQUIPMENT

1 Electrical equipment

1.1 Transformers

1.1.1 Transformers are to comply with IEC Publication 60092-303.

1.1.2 Transformers are to be installed in well-ventilated locations.

1.1.3 The connections of transformers are to be protected against such mechanical damage, condensation and corrosion as may be reasonably expected.

1.2 Converters

1.2.1 Semiconductor converters are to conform with IEC Publication 60146.

1.2.2 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.

1.2.3 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.

1.2.4 Converters are not to be mounted near sources of heat such as engine exhaust pipes.

1.3 Rotating machines

1.3.1 The requirements of IEC Publication 60034 series and IEC Publication 60092-301 are to be applied.

1.4 Switchgear and control gear

1.4.1 Switchgear and control gear assemblies are to be in accordance with IEC Publication 60092-302.

1.5 Storage batteries

1.5.1 *(1/1/2022)*
Where batteries other than Lead and Nickel-Cadmium and Nickel-Metal-Hydride batteries are installed the requirements of App 2 are to be complied with.

2 Miscellaneous equipment

2.1 Lighting fittings

2.1.1 Lighting fittings are to be so arranged as to prevent temperature rises which could damage the cables and wiring.

2.1.2 Where the temperature 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.

2.1.3 Lighting fittings are to be so arranged as to prevent surrounding material from becoming excessively hot.

2.1.4 Lighting fittings are to be secured in place such that they cannot be displaced by the motion of the vessel.

2.2 Heating appliances

2.2.1 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. 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.

2.2.2 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.

2.2.3 Combustible materials in the vicinity of space heaters are to be protected by suitable incombustible and thermal- insulating materials.

2.2.4 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.

3 Lightning protection

3.1 General

3.1.1 Yacht which are of non metallic construction or have non metallic masts are to be fitted with lightning protection.

3.1.2 Lightning conductors are to be made of copper (strip or stranded) and are to be not less tham 70 mm2 in cross section. They are to be secured to a copper spike not less than 12 mm in diameter, projecting at least 300 mm above the top of the mast. The lower end of the conductor is to be earthed.

3.1.3 Lightning conductors are to be installed external to the vessel. They should run as straight as possible and sharp bends should be avoided.

3.1.4 Bolted, riveted joints only are to be used. No welded connection is allowed.

3.1.5 If the hull is metallic, the lower end of the lightning conductor is to be earthed to the hull.

3.1.6 If the hull is non-metallic, the lower end of the lightning conductor is to be connected to an earthing plate of copper or other conducting material compatible with sea water, not less than 0,25 m2 in surface area, secured to the outside of the hull in an area reserved for this purpose and located below the light load water line so that it is immersed under all conditions of heel.

3.1.7 The earthing plate for the lightning conductor is to be additional to, and separate from, the earthing plate used for the power system earthing or earth bonding system.

SECTION 7 ELECTRICAL PROPULSION PLAN

1 General

1.1 Applicable requirements

1.1.1 The following requirements apply to yacht's 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 8 apply.

1.1.4 Cooling and lubricating oil systems are to comply with the requirements of Ch 1, Sec 9.

1.1.5 Monitoring and control systems are to comply with the requirements of Ch 3.

1.1.6 Installation assigned the additional notation for automation is to comply with the requirements of Part E.

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 yacht 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 yacht 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 reserved for this purpose and be electrically separate from other electrical systems on board or may be supplied from a central power generation plant, which supplies the yacht's services and electric propulsion.

When the electrical production used for propulsion is independent of the shipboard production, the diesel engines driving the electric generators, dedicated to the propulsion system, 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 yacht's auxiliary services, see Sec. 6.

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.

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 yachts 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 deexcite 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 URM are to be used as a base for each semiconductor valve:

- when connected to a supply specifically for propeller drives:

  URM = 1,5 UP
- when connected to a common main supply:

  URM = 1,8 UP

where:

UP : 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 acceptable limits for the correct operation of all electrical devices.

4 Control and monitoring

4.1 Power plant control systems

4.1.1 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.

4.1.2 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.

4.1.3 Failure of the power plant control system is not to cause complete loss of generated power (i.e. blackout) or loss of propulsion.

4.1.4 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.

4.1.5 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.

4.1.6 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.

4.1.7 Where the electric propulsion system is supplied by the main switchboard together with the yacht'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.

4.1.8 The risk of blackout due to electric propulsion operation is to be eliminated. At the request of Tasneef a failure mode and effects analysis is to be carried out to demonstrate the reliability of the system

4.2 Indicating instruments

4.2.1 In addition to the provisions of Chapter 3, instruments indicating consumed power and power available for propulsion are to be provided at each propulsion remote control position.

4.2.2 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.

4.2.3 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.

4.2.4 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.

4.2.5 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.

4.2.6 An ammeter is to be provided on the supply circuit for each propulsion semiconductor bridge.

4.3 Alarm system

4.3.1 An alarm system is to be provided, in accordance with the requirements of Chapter 3, Section 2. The system is to give an indication at the control positions when the parameters specified in [4.4.4] assume abnormal values or any event occurs which can affect the electric propulsion.

4.3.2 Where an alarm system is provided for other essential equipment or installations, the alarms may be connected to such system.

4.3.3 Critical alarms for propulsion may be grouped, but are to be indicated to the bridge separately from other alarms.

4.3.4 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.

4.4 Reduction of power

4.4.1 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

4.4.2 When power is reduced automatically, this is to be indicated at the propulsion control position (critical alarm).

4.4.3 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.

SECTION 8 TESTING

1 General

1.1 Rule application

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 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 Insulation resistance

2.1 Lighting and power circuits

2.1.1 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.

2.2 Internal communication circuits

2.2.1 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.

2.2.2 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.

2.2.3 If necessary, any or all appliances connected to the circuit may be disconnected while the test is being conducted.

2.3 Switchboards

2.3.1 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, section board, etc is to be not less than 1 MΩ.

2.3.2 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.

2.4 Generators and motors

2.4.1 The insulation resistance of generators and motors, in normal working condition and with all parts in place, is to be measured and recorded.

2.4.2 The test is to be carried out with the machine hot immediately after running with normal load.

2.4.3 The insulation resistance of generator and motor connection cables, field windings and starters is to be at least 1 MΩ.

3 Earth

3.1 Electrical constructions

3.1.1 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.

3.2 Metal-sheathed cables, metal pipes or conduits

3.2.1 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.

4 Operational tests

4.1 Generating sets and their protective devices

4.1.1 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.

4.1.2 Load variations which are expected in normal craft operation are to be applied to verify the satisfactory operation under steady state and transient conditions of:

- voltage regulators
- speed governors.

4.1.3 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.

4.1.4 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.

4.1.5 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.

4.2 Switchgear

4.2.1 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.

4.3 Consuming devices

4.3.1 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.

4.3.2 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.

4.3.3 The remote stops foreseen are to be tested.

4.3.4 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).

4.4 Communication systems

4.4.1 Communication systems, order transmitters and mechanical engine-order telegraphs are to be tested to verify their suitability.

4.5 Installations in areas with a risk of explosion

4.5.1 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.

4.6 Voltage drop

4.6.1 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, [8.9.4]).

5 Testing for ✠ MACH notation assignment

5.1 Testing of rotating machines

5.1.1 The tests indicated in [5.1] to [5.5] are to be carried out where the ✠ **MACH** notation is requested.

The test indicated in [5.6] and relevant to the main switchboard is due both for the ✠ **MACH** notation and for the ● **MACH** notation.

All machines are to be tested by the Manufacturer

5.1.2 Manufacturer's test records are to be provided for machines for essential services, for other machines they are to be available upon request.

5.1.3 All tests are to be carried out according to IEC 60092-301.

5.1.4 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 Tasneef during testing and, if appropriate, during manufacturing.

Note 1: An alternative inspection scheme may be agreed by Tasneef with the Manufacturer whereby the attendance of the Surveyor will not be required as indicated above.

5.2 Shaft material

5.2.1 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 Tasneef

5.2.2 Shaft material for other machines is to be in accordance with recognised international or national standards.

5.3 Tests

5.3.1 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.

5.4 Description of the test

5.4.1 Examination of the technical documentation, as appropriate, and visual inspection

Technical documentation of machines rated at 100kW (kVA) and over is to be available for examination by the Surveyor.

A visual examination of the machine is to be made to ensure, as far as is practicable, that it complies with the technical documentation.

5.4.2 Insulation resistance measurement

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.

5.4.3 Winding resistance measurement

The resistances of the machine windings are to be measured and recorded using an appropriate bridge method or voltage and current method.

Table 1 : Tests to be carried out on electrical rotating machines

N°	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
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	$U_n/1000 + 1$
$7200 < U_n \leq 15000$	5000	$U_n/1000 + 1$

5.4.4 Verification of the voltage regulation system

The alternating current generator, together with its voltage regulation system, is to be verified in such a way that, at all loads from no load running to full load, the rated voltage at the rated power factor is maintained under steady conditions within ± 2.5%. These limits may be increased to ± 3.5% for emergency sets.

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.

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.

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.

5.4.5 Rated load test and temperature rise measurements

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 Publication 60034-1, or by means of a combination of other tests.

The limits of temperature rise are those specified in Table 6 of IEC Publication 60034-1 adjusted as necessary for the ambient reference temperatures.

5.4.6 Overload/overcurrent tests

The overload test is to be carried out as a type test for generators as proof of overload capability of generators and the excitation system, and for motors as proof of momentary excess torque as required in IEC Publication 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).

In the case of machines for special uses (e.g. for windlasses), overload values other than the above may be considered.

5.4.7 Verification of steady short-circuit conditions

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.

5.4.8 Overspeed test

Machines are to withstand the overspeed test as specified in IEC Publication 60034-1. This test is not applicable for squirrel-cage motors.

5.4.9 Dielectric strength test

New and completed rotating machines are to withstand a dielectric test as specified in IEC Publication 60034-1.

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 Publication 60034-1.

Completely rewound windings of used machines are to be tested with the full test voltage applied in the case of new machines.

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.

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.

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.

5.4.10 No load test

Machines are to be operated at no load and rated speed while 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.

5.4.11 Verification of degree of protection

As specified in IEC Publication 60034-5.

5.4.12 Verification of bearings

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.

5.5 Testing of transformers

5.5.1 On new transformers intended for essential services the tests specified in Tab 3 are to be carried out.

Table 3 : Tests to be carried out on transformers

N°	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	Voltage drop	X	X
4	High voltage test	X	X
5	Temperature rise measurement	X	
6	Induced voltage test	X	X
7	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 subjected to routine tests 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.

5.5.2 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 Tasneef

5.5.3 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.

5.5.4 For the test procedure, the requirements of IEC 60076 and 60726 apply.

5.5.5 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 Tasneef

Transformers of 5 kVA up to the limit specified above are approved on a case-by-case basis, at the discretion of Tasneef subject to the submission of adequate documentation and routine tests.

5.6 Testing of main switchboard

5.6.1 The tests are to be carried out prior to installation on board. 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.

5.6.2 The test procedures are as specified in IEC Publication 60092-302.

5.6.3 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.

The connections, especially screwed or bolted connections, are to be checked for adequate contact, possibly by random tests.

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.

5.6.4 The high voltage test is to be performed with alternating voltage at a frequency between 25 and 100 Hz of approximately sinusoidal form.

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.

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 1 minute.

The value of the test voltage for main and auxiliary circuits is given in Tab 4 and Tab 5.

Table 4 : Test voltages for main circuits

Rated insulation voltage U_i V	Test voltage c.a (r.m.s.) V
$U_i \le 60$	1000
$60 < U_i \le 300$	2000
$300 < U_i \le 660$	2500
$660 < U_i \le 800$	3000
$800 < U_i \le 1000$	3500

Table 5 : Test voltage for auxiliary circuits

Rated insulation voltage U_i V	Test voltage c.a (r.m.s.) V
$U_i \le 12$	250
$12 < U_i \le 60$	500
$U_i > 60$	$2 U_i + 1000$ (at least 1500)

5.6.5 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. 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 Mohm.

5.7 Certification

5.7.1 Testing certification

a) For yachts having the ✠ **MACH** class notation, Tasneef inspection certificates (see Pt D, Ch 1, Sec 1, [4.2.1] and Pt D, Ch 1, Sec 1, [4.2.2] for alternative inspection scheme) are required for electrical rotating machines, transformers and main switchboard to which [5.1], [5.5] and [5.6] are applicable.

b) For yachts having the ● **MACH** class notation, works' certificates (as indicated in Pt D, Ch 1, Sec 1, [4.2.3]) will be accepted for the same components, excluding the main switchboard, which is in any case required to have Tasneef testing certification.

5.8 Type approved electrical rotating machines, transformers, main switchboard

5.8.1 Issue of Tasneef Type Approval Certificate

For yachts less than 500 GT, when ✠ **MACH class notation** is to be assigned, the electrical rotating machines, transformers and main switchboard to which [5.1], [5.5] and [5.6] are applicable, respectively, are to be type approved by Tasneef

For a particular type of electrical rotating machine or transformer or main switchboard, 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 [5.1] to [5.6].

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 electrical rotating machine or transformer or main switchboard 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.

5.8.2 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 Tasneef

APPENDIX 1 DETAIL OF DOCUMENTATION TO BE SUBMITTED

1 Detail of documentation required for approval

1.1 General

1.1.1 *(1/1/2017)*

The documentation required for approval in Sec 1, [2.1.1] is to include all the information listed in Tab 1.

1.1.2 *(1/1/2017)*

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 *(1/1/2017)*

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 *(1/1/2017)*

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 *(1/1/2017)*

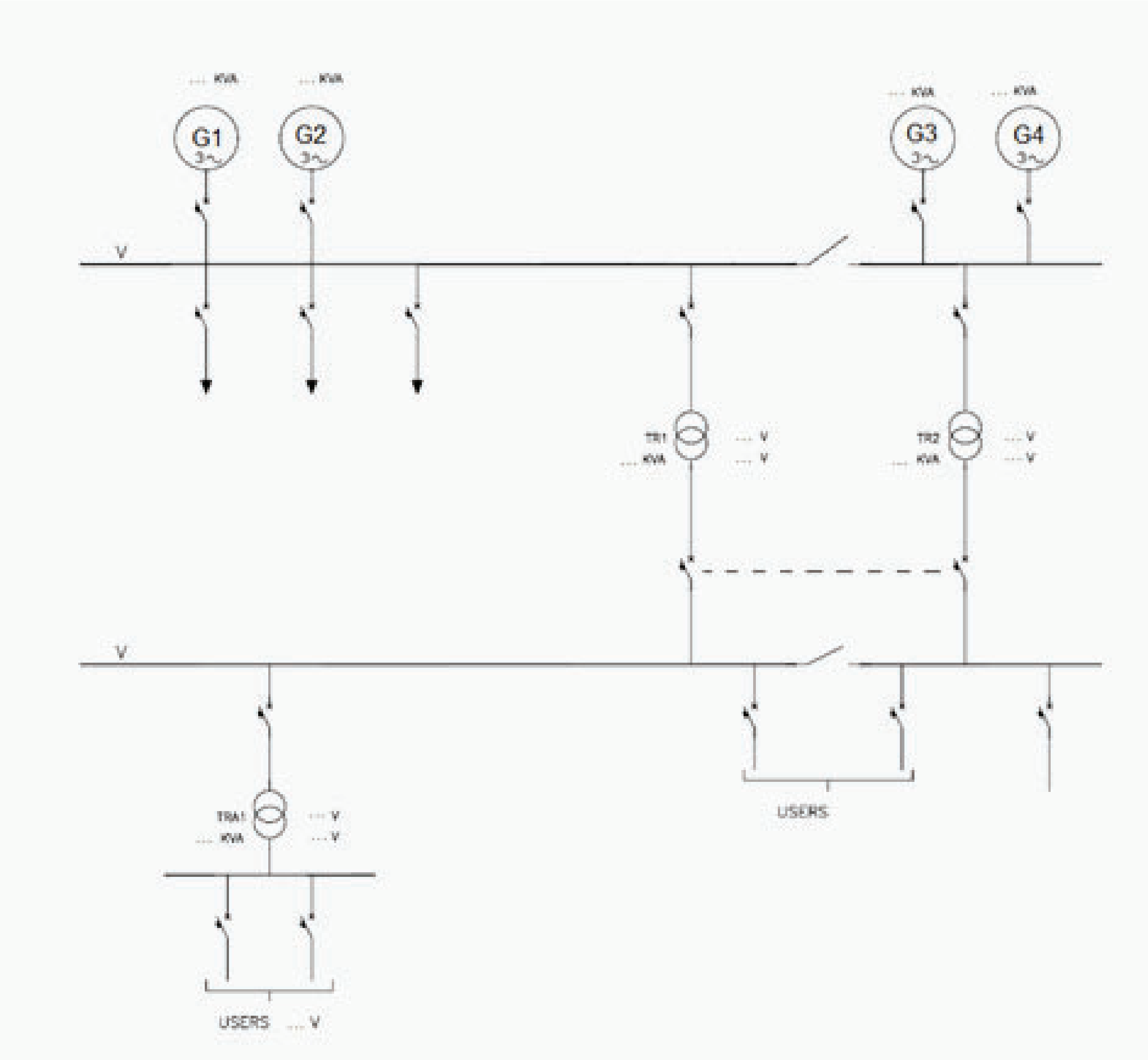


Figure 2 *(1/1/2017)*

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 *(1/1/2017)*

Sheet n. ...		RI																		
DRAWING n. ...	REV. ...	SHORT CIRCUIT CURRENTS															VOLTAGE ... V			
SERVICE		SYMMETRICAL ... KA															FREQUENCY ... Hz			
CIRCUIT		PEAK ... KA																		
				CABLE					CIRCUIT BREAKER				RELAYS				CONTROLS			
ITEM	DESCRIPTION	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 *(1/1/2017)*

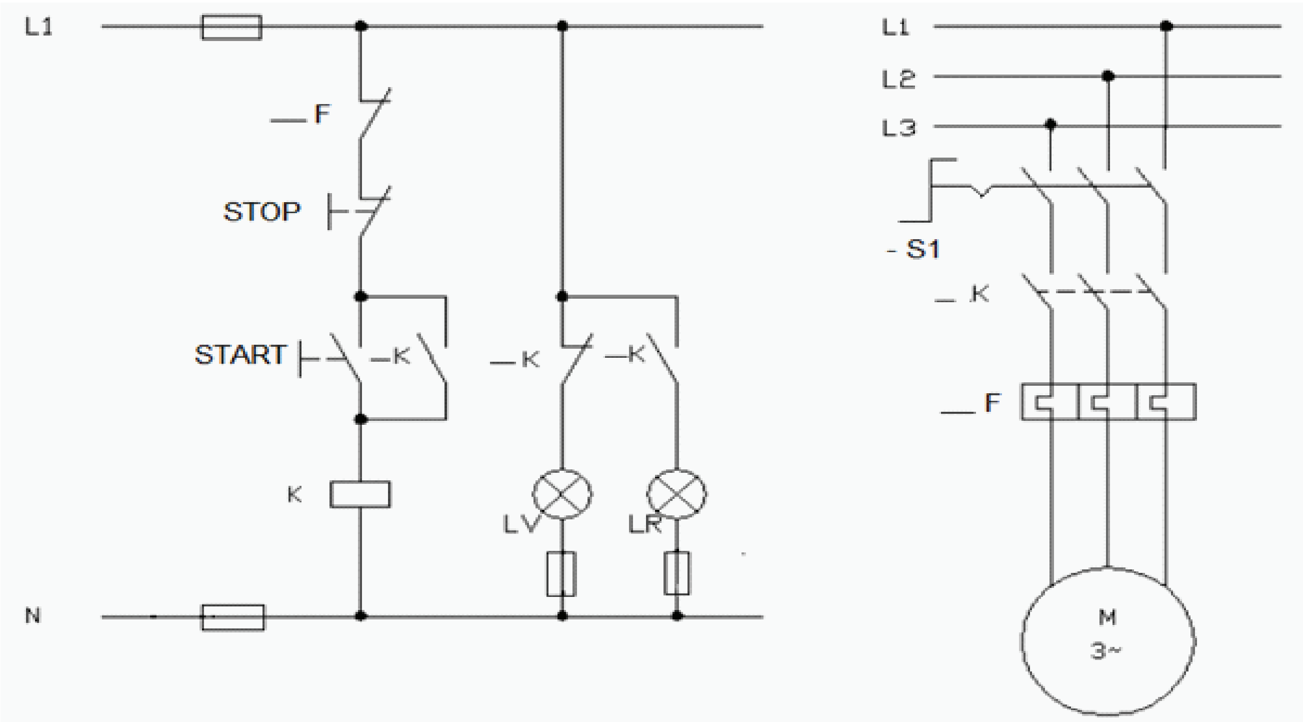
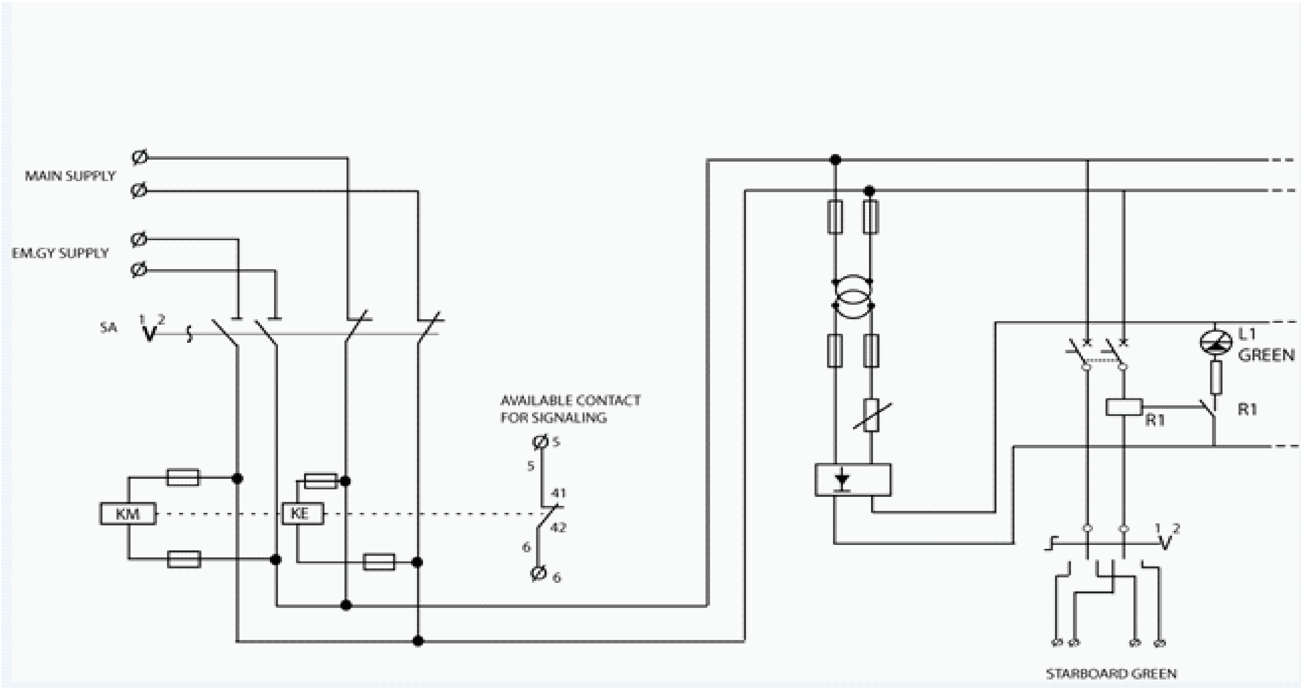


Figure 5 *(1/1/2017)*



APPENDIX 2 BATTERY POWERED YACHTS

1 General

1.1 Application

1.1.1 *(1/1/2022)*

The provisions of this Appendix apply to yachts where batteries, other than Lead, Nickel-Cadmium and Nickel-Metal-Hydride batteries, are installed to supply essential or not-essential services and emergency services, except batteries embedded in small consumer products, unless otherwise stated by Flag Administration.

1.1.2 *(1/1/2022)*

The requirements in this Appendix are applicable in particular 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 *(1/1/2022)*

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 *(1/1/2022)*

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 *(1/1/2022)*

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.

Table 1 : Documentation to be submitted *(1/1/2022)*

No.	A/I **(1)**	Document
1	A	Block diagram and electrical wiring diagram of the battery system and systems interfaced to the battery system, including control, monitoring and alarm system, emergency shutdown, 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 programs which is to include functional tests (alarm system, safety system, control system, etc.) as per [5.2] 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, 62620, 60529 or UN 38.3, when requested by the rules.
10	I	Copy of type approval certificate of batteries and BMS, or of batteries UN 38.3 certificate 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 and disconnection of the 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 applicable and depending on the safety concept adopted.
15	I	Battery system maker statement confirming the suitability of the selected fire extinguishing system and ventilation 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 of the space it is being installed in
- the clearance distances between the other ancillary equipment in the space and the battery pack.

2 System design

2.1 General

2.1.1 *(1/1/2022)*

When batteries are used as storage of power for the propulsion , steering, 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.

2.1.2 *(1/1/2022)*

Where batteries are used for propulsion and steering of the ship, 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.

2.1.3 *(1/1/2022)*

Cables connecting each battery system to the main switchboard are to be arranged as per Sec 5 [7] and Ch 3, Sec 3 [8.2].

2.1.4 *(1/1/2022)*

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.

2.1.5 *(1/1/2022)*

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 or emergency services and measures to mitigate the related risk,
- to evaluate any risk related to the location of batteries in the same space with and other systems supporting ship's 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 not essential services,
- to address sensor failures and alarm, control and safety systems failures (e.g. BMS and EMS failures including power and communication failures, fire detection system failures, so on),
- to assess the selected fire extinguishing and ventilation arrangement according to battery system maker guidelines considering the specific design features of the ship.

2.1.6 *(1/1/2022)*

Battery cells of different physical characteristics, chemistries and electrical parameters are not to be used in the same electrical circuit.

2.1.7 *(1/1/2022)*

The batteries are to be properly located (see [4]) and, where necessary, insulated to prevent overheating of the system.

2.1.8 *(1/1/2022)*

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 *(1/1/2022)*

Battery enclosure covering modules and cells are to be made of flame retardant materials.

2.2.2 *(1/1/2022)*

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 *(1/1/2022)*

A thermal protection device, capable to disconnect the battery in case of high temperature, is to be provided in the battery.

2.2.4 *(1/1/2022)*

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 *(1/1/2022)*

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 current. External terminal contact surfaces are to be made of conductive materials with good mechanical strength and corrosion resistance. Terminal contacts are to be arranged to minimize the risk of short circuits.

2.2.6 *(1/1/2022)*

The battery system is to be provided with a Battery Management System (BMS) according to [3.2].

2.3 Electrical protection

2.3.1 *(1/1/2022)*

The outgoing circuits of the battery system is to be protected against overload and short-circuit by means of fuses or multipole circuit breakers having isolating capabilities.

2.3.2 *(1/1/2022)*

An emergency shutdown system is to be installed and capable of disconnecting the battery system in an emergency.

2.3.3 *(1/1/2022)*

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 *(1/1/2022)*

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).

2.4.2 *(1/1/2022)*

The battery charger is to be interfaced with and controlled by the BMS.

Any detectable failure in the battery charger, anyway including charging/discharging failure, is to give an alarm in a continuously manned position.

3 Control, monitoring, alarm and safety systems

3.1 General

3.1.1 *(1/1/2022)*

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 *(1/1/2022)*

Control, monitoring, alarm and safety systems are to comply with the requirements of Ch 3.

3.2 Battery management systems (BMS)

3.2.1 *(1/1/2022)*

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 *(1/1/2022)*

In case the BMS needs external power supply (fed from yacht electrical distribution system) then it 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 power supply.

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.

In any case an alarm is to be given in a manned position and safety action taken in the event of loss of all the power supplies.

3.2.3 *(1/1/2022)*

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 *(1/1/2022)*

At least 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:

- system voltage,
- max, min, average cell voltage,
- max, min and average cell or module temperature,
- battery string current.

3.2.5 *(1/1/2022)*

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 *(1/1/2022)*

Abnormal conditions which can develop into safety hazards are to be alarmed before reaching the hazardous level.

3.3.2 *(1/1/2022)*

Any abnormal condition in the battery system is to initiate an alarm.

3.3.3 *(1/1/2022)*

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 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 [2.1.6]) and relevant mitigating measures are to be adopted.

3.3.4 *(1/1/2022)*

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 ship intended operations.

3.4 Safety system

3.4.1 *(1/1/2022)*

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 *(1/1/2022)*

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. Anyway, the risk of unsafe lock or stop of the propulsion system or of blackout due to safety system activation shall be addressed in the Risk Assessment. Manual override of safety functions is not to be possible.

3.4.3 *(1/1/2022)*

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 *(1/1/2022)*

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 *(1/1/2022)*

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 *(1/1/2022)*

When battery installation is used as storage of power for the propulsion, steering 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 *(1/1/2022)*

When battery installation is used as storage of power for the propulsion, steering 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 *(1/1/2022)*

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 *(1/1/2022)*

Sensors are to be designed to withstand the local environment.

3.4.10 *(1/1/2022)*

The enclosure of the sensor and the cable entry are to be appropriate to the space in which they are located.

3.4.11 *(1/1/2022)*

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 *(1/1/2022)*

When required per [2.1.1], 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 can be integrated in the PMS.

The energy management system is to be continuously supplied and a failure is to initiate an alarm in a manned location.

3.5.2 *(1/1/2022)*

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 *(1/1/2022)*

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 *(1/1/2022)*

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 excessive vibration or other conditions which would impair their safety, performance or accelerate deterioration.

4.1.3 *(1/1/2022)*

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 *(1/1/2022)*

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 shall be partially waived.

4.1.5 *(1/1/2022)*

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 *(1/1/2022)*

Batteries, used as storage of power for the propulsion, steering, dynamic positioning systems, or as part of the main source of electrical power, are to be located in a battery space placed within the borders of the main machinery space or adjacent to it. Exceptions will be evaluated on a Risk Assessment basis.

4.1.7 *(1/1/2022)*

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 *(1/1/2022)*

When required, based on [4.1.6] or the Risk Assessment (see [2.1.4]), a space assigned to batteries only is to be foreseen.

4.2.2 *(1/1/2022)*

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 *(1/1/2022)*

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 *(1/1/2022)*

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 *(1/1/2022)*

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 ship's spaces,
- provided with manual stop, fitted outside the space to be ventilated and capable of being operated in all the weather and sea conditions, independent from the automatic and or remote control system,
- provided with indication of ventilation flow and of battery space ambient temperature. In case of low ventilation rate or high ambient temperature, an alarm is to be activated,
- 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 fan driven by a certified safe type electric motor fans in case the ventilation duct is considered to contain explosive atmosphere in case of thermal runaway.

4.2.6 *(1/1/2022)*

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 *(1/1/2022)*

Battery modules with liquid cooling are to be designed such that the risk of a cooling liquid leakage inside the module is minimized. Pumps' failures are to be addressed in the risk assessment [2.1.7].

4.2.8 *(1/1/2022)*

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 *(1/1/2022)*

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 and all electrical equipment non certified of safety type for the specific hazardous area, gas, vapor 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 *(1/1/2022)*

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 *(1/1/2022)*

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 *(1/1/2022)*

Battery spaces are to be insulated in way of other spaces as indicated in Tab 2.

4.2.13 *(1/1/2022)*

Battery spaces are to be considered as spaces not normally manned.

4.2.14 *(1/1/2022)*

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 *(1/1/2022)*

Bulkhead	Control Station	Corridor	Accomodation spaces	Stairways	Service spaces (low risk)	Machinery Space of cat A	Machinery Space	Service spaces (high risk)	Open deck	Muster stations
Li Battery Space	A60	A15	A30	A15	A0	A60	A0	A30	A0	A60
Li Battery Space Below	A60	A60	A30	A60	A0	A60	A0	A30	A0	A60
Li Battery Space Above	A60	A0	A0	A0	A0	A60	A0	A0	A0	A60

5 Testing

5.1 General

5.1.1 *(1/1/2022)*

Batteries systems are to be tested by the Manufacturer.

5.1.2 *(1/1/2022)*

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 *(1/1/2022)*

On yachts with LH of at least 24m (according to ISO 8666), 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 *(1/1/2022)*

Battery systems are to be tested by the Manufacturer according to a test program proposed by the Manufacturer to be 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.

5.2.2 *(1/1/2022)*

As a minimum, the tests and inspections listed in Table 3 are to be carried out. A tests report shall be issued.

Table 3 *(1/1/2022)*

Item	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)**
(1) Refer to Tasneef Rules for Yachts Designed for Commercial Use Pt C, Ch 2, Sec 8, [5.6.4] and [5.6.5]. In order to prevent damages to the electronic components of the battery system, the electronic components can be disconnected during the high voltage test.	

Item	Test/inspection
5	Sensor failure test (e.g. power supply failure, disconnection, short circuit)
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 Tasneef Rules for Yachts Designed for Commercial Use Pt C, Ch 2, Sec 8, [5.6.4] and [5.6.5]. 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 *(1/1/2022)*

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 *(1/1/2022)*

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.

Table 4 *(1/1/2022)*

Item	
1	Insulation resistance test
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 communication 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 [3.2.5]) **(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 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).	

5.4 Plans to be kept on board

5.4.1 *(1/1/2022)*

An operation manual is to be kept on board which includes at least:

- charging procedure,
- normal operation procedures, including instructions for the safe connection and disconnection of the batteries,
- emergency operation procedures,
- estimated battery deterioration (ageing) rate curves, considering modes of operation.

5.4.2 *(1/1/2022)*

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.

Part C

Machinery, Electrical Installations, Automation and Fire Protection

Chapter 3

AUTOMATION

SECTION 1	GENERAL REQUIREMENTS
SECTION 2	DESIGN REQUIREMENTS
SECTION 3	COMPUTER BASED SYSTEMS
SECTION 4	CONSTRUCTIONAL REQUIREMENTS
SECTION 5	INSTALLATION REQUIREMENTS
SECTION 6	TESTING
APPENDIX 1	INSTALLATIONS

SECTION 1 GENERAL REQUIREMENTS

1 General

1.1 Field of application

1.1.1 The requirements of this Chapter apply to automation systems on yachts which have a length of at least 24 m but less than 50 m, or which have a gross tonnage less than 500. In particular, they apply to the components of automation systems for:

- services essential to the propulsion, steering and safety of the yacht and
- services for habitability.

1.1.2 This Chapter is intended to prevent failures or malfunctions of automation systems associated with essential and non-essential services from causing danger to other essential services.

1.1.3 For yachts which have a length equal to or greater than 50 m, or which have a gross tonnage of 500 and above, Part C, Ch 3 of Tasneef Rules applies.

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

The following definitions 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.
- 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.
- 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.
- Computer based 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.
- 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 yacht, 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.
- 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 Main and auxiliary machinery essential for the propulsion, control and safety of the yacht are to be provided with effective means for its operation and control.

1.4.2 Control, alarm and safety systems are to be based on the fail-to-safety principle.

1.4.3 Failure of automation systems is to generate an alarm.

1.4.4 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 ship builder is to submit to Tasneef 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.

Tasneef 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.

Unless otherwise agreed with Tasneef documents for approval are to be sent in triplicate if submitted by the shipyard and in four copies if submitted by the equipment supplier.

In any case, Tasneef reserves the rights to require additional copies, when deemed necessary.

2.2 Documents to be submitted

2.2.1 The following documents are to be submitted:

- The general specification for the automation of the craft
- The detailed specification of the essential service automation systems
- The diagrams of the supply circuits of automation systems, identifying the power source
- The list of monitored parameters for alarm/monitoring and safety systems

3 Environmental and supply conditions

3.1 General

3.1.1 Environmental conditions

The automation system is to be designed to operate satisfactorily in the environment in which it is located.

3.1.2 Failure behavior

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 is to 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.

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.

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.

SECTION 2 DESIGN REQUIREMENTS

1 System Design

1.1 General

1.1.1 All control systems essential for the propulsion, control and safety of the yacht are to 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 is not to 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 computer based 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 The automation system is to be continuously powered.

2.1.2 Failure of the power supply is to generate an alarm.

2.2 Electrical power supply

2.2.1 The power supply is to be protected against short-circuit and overload for each independent automation system.

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 1 and Chapter 2.

It is also to 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 is to 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 are to include provision 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 is to be such that in the event 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 Tasneef 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 electrical, pneumatic or hydraulic supply to the system.

4.1.4 *(1/1/2016)*

Propulsion machinery orders from the navigation bridge are to be indicated in the main machinery control room and at the manoeuvring platform from which the engines are normally controlled where such locations are effectively existing. Other requirements are to be considered under the application of specific Safety Codes issued by the relevant Administrations, if any.

4.1.5 The control is to 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 are to be controlled by one control device.

4.1.6 Indicators are to 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 is to be provided with an emergency stopping device on the navigation bridge which is to 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 are to be provided for preventing overload and running in critical speed ranges of the propulsion machinery.

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.

4.2.4 Remote control of the propulsion machinery is to be possible only from one location at a time; interconnected control positions are permitted at such locations.

4.2.5 The transfer of control between the navigating bridge and machinery spaces is to be possible only in the main machinery space or the main machinery control room. The system is to include means to prevent the propelling thrust from altering significantly when transferring control from one location to another.

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).

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 are to be provided with automatic shut-off arrangements in 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.

4.3.6 For steam turbines, a slow turning device is to be provided which operates automatically if the turbine is stopped longer than admissible. Discontinuation of this automatic turning from the bridge is to be possible.

4.4 Automatic control of propulsion and manoeuvring yachts

4.4.1 When the power source actuating the automatic control of propelling yachts 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.

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 control braking is to be possible only if:

- propulsion power has been shut off
- the turning gear is disconnected
- the shaft line speed (r.p.m.) is below the threshold stated by the builder.

5 Remote control of valves

5.1 General

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 acknowledgement 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 is not to prevent the audible signal from operating for a new alarm. Alarms are to be maintained until they are acknowledged and visual indications of individual alarms are to remain until the fault has been corrected, when the alarm system is to 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 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.

6.2.6 Alarm systems with limited number of monitored positions

For alarms with a limited number of monitored positions, relaxation of the requirements of [6.2] may be granted at the discretion of Tasneef

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 yacht), 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 yacht, 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 yacht 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.

SECTION 3 COMPUTER BASED SYSTEMS

1 General requirements

1.1 General

1.1.1 The characteristics of the system are to be compatible with the intended applications, under normal and abnormal process conditions. The response time for the alarm function is to be less than 5 seconds.

1.1.2 When systems under control are required to be duplicated and in separate compartments, this is also to apply to control elements within computer based systems.

1.2 System operation

1.2.1 The system is to be protected so that only authorised personnel can modify any setting which could alter the system.

1.2.2 Modification of the configuration, set points or parameters is to be possible without complex operations such as compilation or coded data insertion.

1.2.3 Program and data storage of the system is to be designed so as not to be altered by environmental conditions or loss of the power supply.

1.3 System failure

1.3.1 In the event of failure of a computer based system, the process is to automatically revert to a predefined condition providing an appropriate level of safety. Failure is to initiate an audible and visual alarm.

1.3.2 A self-monitoring device is to be implemented so as to check the proper function of hardware and software in the system. This is to include a self-check facility of input/output cards, as far as possible.

1.3.3 The failure and restarting of computer based systems is not to cause processes to enter undefined or critical states.

1.4 System redundancy

1.4.1 If it is demonstrated that the failure of the system, which includes the computer based system, leads to a major fault causing danger to the essential services as well as to the safety of the craft, then a secondary independent means, of appropriate diversity, is to be available to restore the basic functionality of the service.

2 Hardware

2.1 General

2.1.1 The construction of systems is to comply with the requirements of Sec 4.

2.2 Housing

2.2.1 The housing of the system is to be designed to withstand the environmental conditions in which it will be installed. The design will be such as to protect the printed circuit board and associated components from external aggression. When required, the cooling system is to be monitored, and an alarm activated when the normal temperature is exceeded.

2.2.2

The mechanical construction is to be designed to withstand the vibration levels defined in [7].

3 Software

3.1 General

3.1.1 The basic software is to be developed in consistent and independent modules.

A self-checking function is to be provided to identify failure of a software module.

When hardware (e.g. input /output devices, communication links, memory, etc.) is arranged to limit the consequences of failures, the corresponding software is also to be separated in different software modules ensuring the same degree of independence.

3.2 Software Development Quality

3.2.1 Software development is to be carried out according to a quality plan defined by the builder and records are to be kept. ISO 9000-1, or an equivalent international standard, is to be taken as guidance for the quality procedure. The quality plan is to include the test procedure for software and the results of tests are to be documented.

4 Data transmission link

4.1 General

4.1.1 The performance of the network transmission medium (transfer rate and time delay) is to be compatible with the intended application.

4.1.2 When the master /slave configuration is installed, the master terminal is to be indicated on the other terminals.

4.2 Hardware support

4.2.1 The data transmission is to be self-checked, regarding both the network transmission medium and the interfaces/connections. The data communication link is to be automatically started when power is turned on, or restarted after loss of power.

4.2.2 The choice of transmission cable is to be made according to the environmental conditions. Particular attention is to be given to the level characteristics required for electromagnetic interference.

4.2.3

The installation of transmission cables is to comply, as applicable, with the requirements stated in [8]. In addition, the routing of transmission cables is to be chosen so as to be in less exposed zones regarding mechanical, chemical or EMI (ElectroMagnetic Interference) damage. As far as possible, the routing of each cable is to be independent of any other cable. These cables are not normally allowed to be routed in bunches with other cables on the cable tray.

4.2.4 The coupling devices are to be designed, as far as practicable, so that in the event of a single fault, they do not alter the network function. When a failure occurs, an alarm is to be activated. Addition of coupling devices is not to alter the network function. Hardware connecting devices are to be chosen, when possible, in accordance with international standards.

4.3 Transmission software

4.3.1 The transmission software is to be so designed that alarm or control data have priority over any other data. For control data, the transmission time is not to jeopardise efficiency of the functions.

4.3.2 The transmission protocol is preferably to be chosen from international standards.

4.3.3 A means of transmission control is to be provided and designed so as to verify the completion of the data transmitted (CRC or equivalent acceptable method). When corrupted data is detected, the number of retries is to be limited so as to keep an acceptable global response time. The duration of the message is to be such that it does not block the transmission of other stations.

4.4 Transmission operation

4.4.1 When a hardware or software transmission failure occurs, an alarm is to be activated. A means is to be provided to verify the activity of transmission and its proper function (positive information).

4.5 Redundant network

4.5.1 Where two or more essential functions are using the same network, redundant networks are required according to the conditions mentioned in [1.6.1].

4.5.2 Switching of redundant networks from one to the other is to be achieved without alteration of the performance.

4.5.3 When not in operation, the redundant network is to be permanently monitored so that any failure of either network may be readily detected. When a failure occurs in one network, an alarm is to be activated.

4.5.4 In redundant networks, the two networks are to be mutually independent. Failure of any common components is not to result in any degradation in performance.

4.5.5 When redundant data communication links are required, they are to be routed separately, as far as practicable.

5 Man-machine interface

5.1 General

5.1.1 The design of the operator interface is to follow ergonomic principles. The standard IEC 60447 "Man-machine interface" or an equivalent recognised standard may be used.

5.2 System functional indication

5.2.1 A means is to be provided to verify the activity of the system, or subsystem, and its proper function.

5.2.2 A visual and audible alarm is to be activated in the event of malfunction of the system, or subsystem. This alarm is to be such that identification of the failure is simplified.

5.3 Input devices

5.3.1 Input devices are to be positioned such that the operator has a clear view of the related display. The operation of input devices, when installed, is to be logical and correspond to the direction of action of the controlled equipment. The user is to be provided with positive confirmation of action. Control of essential functions is only to be available at one control station at any time. Failing this, conflicting control commands are to be prevented by means of interlocks and/or warnings.

5.3.2 When keys are used for common/important controls, and several functions are assigned to such keys, the active function is to be recognisable. If use of a key may have unwanted consequences, provision is to be made to prevent an instruction from being executed by a single action (e.g. simultaneous use of 2 keys, repeated use of a key, etc.). Means are to be provided to check the validity of the manual input data into the system (e.g. checking the number of characters, range value, etc.).

5.3.3 If use of a push button may have unwanted consequences, provision is to be made to prevent an instruction from being executed by a single action (e.g. simultaneous use of 2 push buttons, repeated use of push buttons, etc.). Alternatively, this push button is to be protected against accidental activation by a suitable cover, or use of a pull button, if applicable.

5.4 Output devices

5.4.1 VDUs (Video Display Units) and other output devices are to be suitably lighted and dimmable when installed in the wheelhouse. The adjustment of brightness and colour of VDUs is to be limited to a minimum discernible level. When VDUs are used for alarm purposes, the alarm signal, required by the Rules, is to be displayed whatever the other information on the screen. The alarms are to be displayed according to the sequence of occurrence. When alarms are displayed on a colour VDU, it is to be possible to distinguish the alarm in the event of failure of a primary colour. The position of the VDU is to be such as to be easily readable from the normal position of the personnel on watch. The size of the screen and characters is to be chosen accordingly. When several control stations are provided in different spaces, an indication of the station in control is to be displayed at each control station. Transfer of control is to be effected smoothly and without interruption to the service.

5.5 Workstations

5.5.1 The number of workstations at control stations is to be sufficient to ensure that all functions may be provided with any one yacht out of operation, taking into account any functions which are required to be continuously available.

5.5.2 Multifunction workstations for control and display are to be redundant and interchangeable.

5.5.3 The choice of colour, graphic symbols, etc is to be consistent in all systems on board.

5.6 Computer dialogue

5.6.1 The computer dialogue is to be as simple and self-explanatory as possible. The screen content is to be logically structured and show only what is relevant to the user. Menus are to be organised so as to have rapid access to the most frequently used functions.

5.6.2 A means to go back to a safe state is always to be accessible.

5.6.3 A clear warning is to be displayed when using functions such as alteration of control condition, or change of data or programs in the memory of the system.

5.6.4 A 'wait' indication is to warn the operator when the system is executing an operation.

6 Integrated systems

6.1 General

6.1.1 Operation with an integrated system is to be at least as effective as it would be with individual, standalone equipment.

6.1.2 Failure of one part (individual module, equipment or subsystem) of the integrated system is not to affect the functionality of other parts, except for those functions directly dependant on information from the defective part.

6.1.3 A failure in connection between parts, card connections or cable connections is not to affect the independent functionality of each connected part.

6.1.4 Alarm messages for essential functions are to have priority over any other information presented on the display.

7 Vibrations

7.1

7.1.1

In relation to the location of the electrical components, the vibration levels given in Tab 1 are to be assumed.

7.1.2

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.

Table 1 : Vibration levels

Location	Frequency range Hz	Displacement amplitude mm	Acceleration amplitude g
Machinery spaces, command and control stations, accommodation spaces, exposed decks, cargo spaces	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

8 Cable runs

8.1 General

8.1.1

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.

8.1.2

Cable runs are to be selected so as to avoid action from condensed moisture and from dripping of liquids.

8.1.3

Connection and draw boxes are to be accessible.

8.1.4

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.

8.2 Location of cables in relation to the risk of fire and overheating

8.2.1

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.

8.2.2

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.

8.2.3

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, section 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.

8.2.4

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.

8.2.5

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.

8.3 Location of cables in relation to electromagnetic interference

8.3.1

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.

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 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.

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.

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 made between any electrical components and liquids, if they are in the same enclosure. Necessary drainage is to 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 interference.

Special precautions are to be taken for:

- measuring elements such as the analogue amplifier or analogue/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 Automation consoles

3.1 General

3.1.1 Automation consoles are to be designed on ergonomic principles.

3.2 Indicating instruments

3.2.1 The operator is to receive feedback information on the effects of his orders.

3.2.2 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.

3.2.3 The instruments are to be clearly labelled. When installed in the wheelhouse, all lighted instruments of consoles are to be dimmable, where necessary.

3.3 VDUs and keyboards

3.3.1 VDUs 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.

3.3.2 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.

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 are to be chosen 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 Electrical connections are to be arranged for easy replacement and testing of sensors and components. They are to be clearly marked.

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 App 1, [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 cableways 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 App 1, [7.2].

For coaxial 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 coaxial 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.

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 commissioned when installed on board and prior to sea trials, to verify their performance and adaptation on site.

1.1.2

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 of the performance and functionality according to Tab 1.

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. Alternatively, adequate spare parts are to be provided. In addition, a blackout test is to be carried out to show that automation systems are continuously supplied.

Upon completion of the commissioning tests, test reports are to be made available to the Surveyor.

Table 1 : 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 INSTALLATIONS

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 and/or boiler rooms.

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 ship'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 ship'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 ship's structure

2.4.1

Every connection of an earth-continuity conductor or earthing lead to the ship'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.

2.5 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 athwartship, 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 for small ships.

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 Section boards and distribution boards

6.3.1

For the installation of section and 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 second deck or approximately 6 metres for verticals runs and every 14 metres for horizontal runs in enclosed and semi-enclosed spaces
   - at the boundaries of the spaces in cargo areas.

c) the use of fire protection coating applied to at least 1 metre in every 14 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

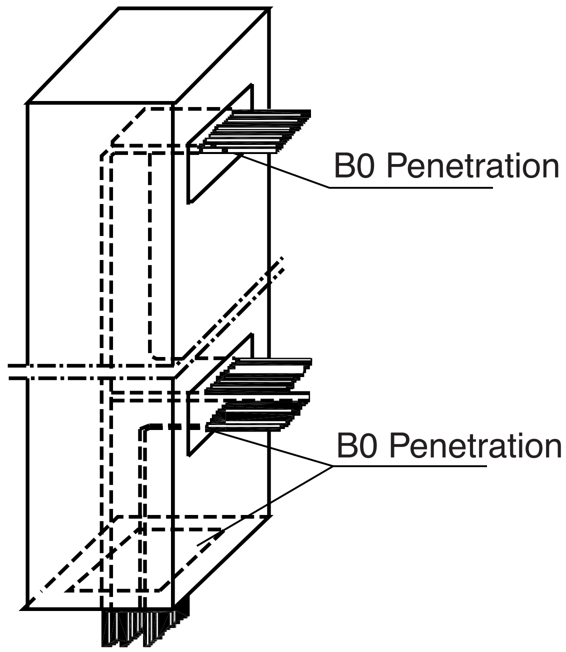


Table 2 : Bending radii

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

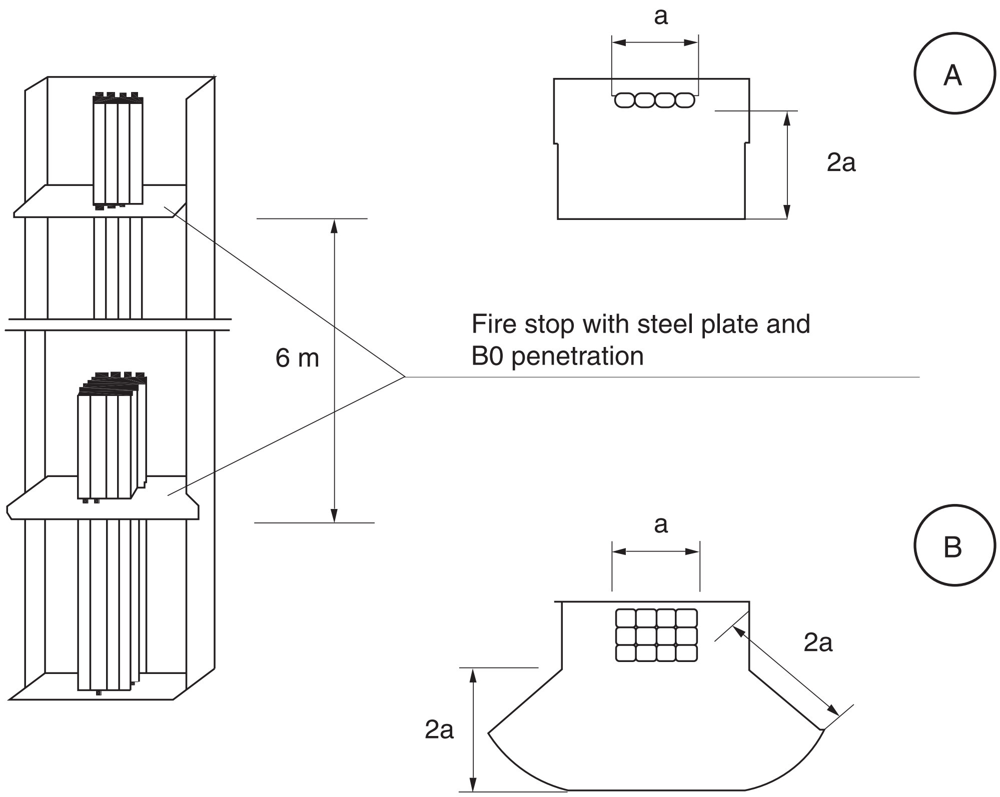


Figure 3 : Non-totally enclosed trunks, horizontal

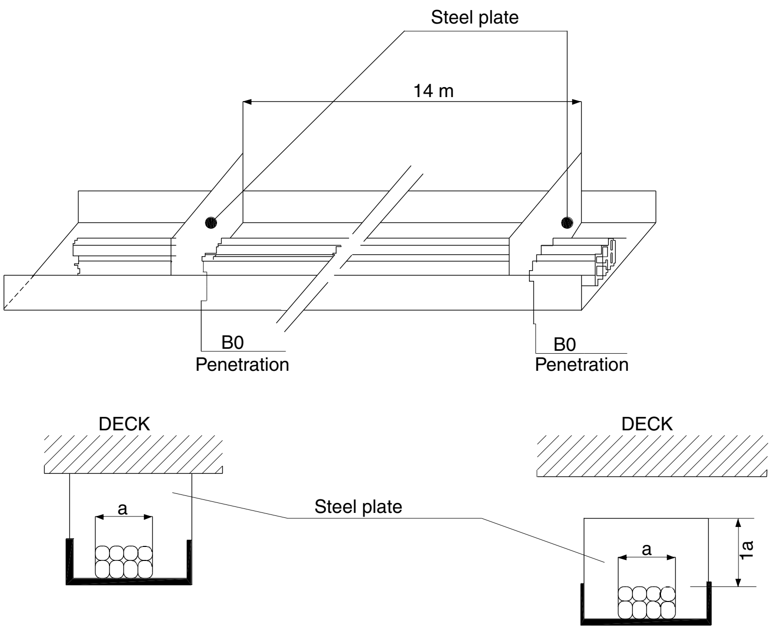
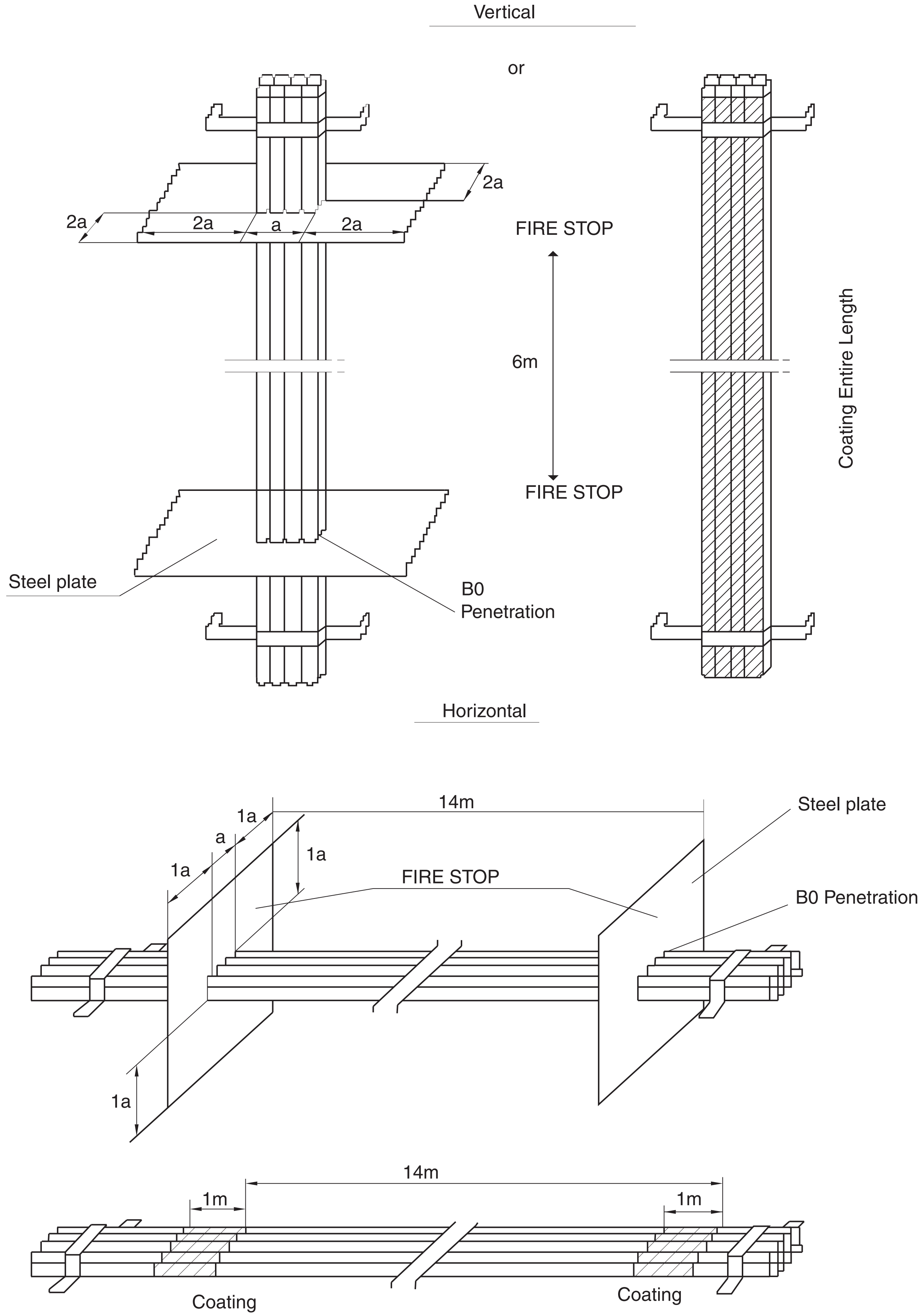


Figure 4 : Open cables runs



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, cargo spaces, etc., cables are to be protected by metal casing, trunkings or conduits, even when armoured, if the ship'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 ship, 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 ship.

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 one and only in those installations (mineral-insulated cables, intrinsically safe circuits, control circuits 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 midpoint).

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.

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 Ch 2, Sec 3, [8.8]), 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.

Part C

Machinery, Electrical Installations and Automation

Chapter 4

FIRE PROTECTION

SECTION 1	GENERAL REQUIREMENTS
SECTION 2	FIRE PREVENTION
SECTION 3	FIRE CONTAINMENT
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APPENDIX 1	OPEN FLAME GAS INSTALLATIONS
APPENDIX 2	FIXED GAS FIRE-EXTINGUISHING SYSTEM ADDITIONAL REQUIREMENTS

SECTION 1 GENERAL REQUIREMENTS

1 Definitions

1.1 Accommodation spaces

1.1.1 Spaces used for public spaces, corridors, stairs, lavatories, cabins, offices, hospitals, cinemas, games and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.

1.2 A class divisions

1.2.1 Divisions formed by bulkheads and decks which comply with the following criteria:

a) they are constructed of steel or other equivalent material or alternative forms of construction to be in compliance with the requirements of this Section;

b) they are suitably stiffened;

c) they are insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180°C above the original temperature, within the time listed below:
- class "A-60" ....60 min
- class "A-30" ....30 min
- class "A-15"..15 min
- class "A-0"..0 min

d) they are so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test.

Tasneef will require a test of a prototype bulkhead or deck in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity or temperature rise. The products indicated in Tab 1 may be installed without testing or approval.

1.3 B class division

1.3.1 Divisions formed by bulkheads, decks, ceilings or linings which comply with the following criteria:

a) they are constructed of approved non-combustible materials and all materials entering into the construction and erection of B class divisions are non-combustible, with the exception that combustible veneers may be permitted provided they meet the other appropriate requirements of this Chapter;

b) they have an insulation value such that the average temperature of the unexposed side will not rise more than 140° C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225° C above the original temperature, within the time listed below:
- class "B-15" ....15 min
- class "B-0" ....0 min

c) they are so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test.

Tasneef will require a test of a prototype division in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity or temperaturise.

In order to be defined as B class, a metal division is to have plating thickness not less than 2 mm when constructed of steel.

1.4 Bulkhead deck

1.4.1 The uppermost deck up to which the transverse watertight bulkheads are carried.

Table 1

Classification	Product description
class "A - 0" bulkhead	A steel bulkhead with dimensions not less than the minimum dimensions given below: • thickness of plating: 4 mm • stiffeners 60 x 60 x 5 mm spaced at 600 mm or structural equivalent
class "A - 0" deck	A steel deck with dimensions not less than the minimum dimensions given below: • thickness of plating: 4 mm • stiffeners 95 x 65 x 7 mm spaced at 600 mm or structural equivalent

1.5 C class divisions

1.5.1 Divisions constructed of approved non-combustible materials. They are not required to comply with either requirements relative to the passage of smoke and flame or limitations relative to the temperature rise. Combustible veneers are permitted provided they meet the requirements of this Chapter.

1.6 Combustible material

1.6.1 Any material other than a non-combustible material.

1.7 Continuous B class ceilings and linings

1.7.1 Continuous B class ceilings or linings are those B class ceilings or linings which terminate at an A or B class division.

1.8 Continuously manned central control station

1.8.1 A central control station which is continuously manned by a responsible member of the crew.

1.9 Control station

1.9.1 Spaces in which the yacht's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralised.

1.10 Fire Test Procedures Code

1.10.1 The "International Code for Application of Fire Test Procedures", as adopted by the Maritime Safety Committee of IMO by Resolution MSC.61 (67), as may be amended by IMO.

1.11 Helideck

1.11.1 Purpose-built helicopter landing area located on a yacht including all structure, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

1.12 Helicopter facility

1.12.1 A helideck including any refuelling and hangar facilities.

1.13 Low flame spread

1.13.1 When the surface thus described will adequately restrict the spread of flame, this being determined in accordance with the Fire Test Procedures Code. Non-combustible materials are considered as low flame spread.

However, due consideration will be given by Tasneef to the method of application and fixing.

1.14 Machinery space

1.14.1 *(1/1/2021)*

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

1.15 Machinery space of category A

1.15.1 Spaces and trunks to such spaces which contain either:

a) internal combustion machinery used for main propulsion, or

b) 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

c) any oil fired boiler or fuel oil unit, or

d) incinerators, waste, disposal units, etc which use oil fired equipment.

1.16 Non-combustible material

1.16.1 A material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the Fire Test Procedures Code. In general, products made only of glass, concrete, ceramic products, natural stone, masonry units, common metals and metal alloys are considered as being non-combustible and may be installed without testing and approval.

1.17 Not readily ignitable

1.17.1 When the surface thus described will not continue to burn for more than 20 seconds after removal of a suitable impinging test flame.

1.18 Fuel oil unit

1.18.1 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 including any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0,18 MPa. "Fuel oil unit" includes any equipment used for the preparation and delivery of fuel oil, whether or not heated, to boilers and engines (including gas turbines) at a pressure of more than 0,18 MPa.

1.19 Public spaces

1.19.1 Portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

1.20 Steel or other equivalent material

1.20.1 Any non-combustible material which, by itself or due to insulation provided, had structural and integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test (e.g. aluminium alloy with appropriate insulation).

1.21 Sauna

1.21.1 A hot room with temperatures normally varying between 80°-120°C where the heat is provided by a hot surface (e.g. by an electrically heated oven). The hot room may also include the space where the oven is located and adjacent bathrooms.

1.22 Alternative forms of construction

1.22.1 Any combustible material may be accepted if it can be demonstrated that the material, by itself or due to insulation provided, has structural and fire integrity properties equivalent to A or B Class divisions, or steel as applicable, at the end of the applicable fire exposure to the standard fire test.

1.23 Service spaces

1.23.1 Service spaces: spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, storerooms, workshops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces.

1.24 Standard fire test

1.24.1 *(1/7/2022)*

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.

1.25 Vehicle Spaces

1.25.1 Spaces containing vehicles or craft with fuel in their tanks for their own propulsion.

1.26 Battery charging station

1.26.1 *(1/1/2022)*

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 2.

Table 2 : 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.

2.1.2 Type Approved Products

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, boiler rooms 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.

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, oil fired boilers 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 Construction and arrangement of saunas

3.1 General

3.1.1 *(1/1/2019)*

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 for vessels of 500 GT and over, A-30 for vessels under 500 GT, and B-15 in case of short range yachts of less than 300 GT, against other spaces except those inside of the perimeter.

3.1.2 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.

3.1.3 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 are to be protected by a fire detection and alarm system and an automatic sprinkler system.

4 Construction and arrangement of Thermal Suite (e.g. Steam Room)

4.1

4.1.1 The perimeter of the thermal suite may include changing rooms, showers and toilets.

4.1.2 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.

4.1.3 *(1/7/2022)*

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 or B-0 for Short Range Yachts. 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 or B-0 for Short Range Yachts and pipes leading to the discharge nozzles should be lagged.

4.1.4 If a suite arrangement contains a sauna then the requirements contained in [3.1] are applicable, regardless of the steam generator location.

4.1.5 *(1/1/2019)*

All spaces within the perimeter are to be protected by a fire detection and alarm system.

5 Deep fat frying equipment

5.1 General

5.1.1 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.

6 Space heaters

6.1 General requirements

6.1.1 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.

7 Materials

7.1

7.1.1 *(1/1/2016)*

Except in refrigerated compartments of service spaces, all insulation (e.g. fire and comfort) is to be of non-combustible.

7.1.2 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.

7.1.3 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.

7.1.4 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.

8 Batteries charging station

8.1

8.1.1 *(1/1/2022)*

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 2 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 aluminum 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/m^3. 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.
Aluminum alloy plate		5,5 mm aluminum 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/m^3. 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 for yachts less than 500 GT

3.1.1 *(1/1/2020)*

For unrestricted yachts category A machinery spaces are to be totally enclosed by A-30 class boundaries. For unrestricted yachts 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.

3.1.2 *(1/1/2020)*

For short range yachts of any gross tonnage, category A machinery spaces are to be enclosed by B-15 class divisions. and for yacht of more than 300 GT the galley to be 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.

3.1.3

The above class division is not necessary on the side of yachts having the hull structure made of steel.

3.1.4 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.

3.1.5 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.

3.1.6 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).

3.1.7 For structures in contact with sea water, the required insulation is to extend to at least 300 mm below the lightest waterline.

3.1.8 *(1/1/2017)*

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 Class divisions for yachts of 500 GT and over

3.2.1 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 $4m^2$, 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 m^2 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).

3.2.2 Category A machinery spaces are to be separated from accommodation spaces, service spaces, control stations, stairways and corridors by A-60 class divisions.

3.2.3 In addition, where the hull is built in combustible material, category A machinery spaces and spaces containing internal combustion machinery or oil fired boilers are to be enclosed by A-30 class divisions.

3.2.4 Corridors are to be separated from accommodation spaces, stairways and service spaces with low risk by B-0 class divisions.

3.2.5 Corridors are to be separated from control stations, other machinery spaces and service spaces with high risk by A-0 blass divisions.

3.2.6 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.

3.2.7 For structures in contact with sea water, the required insulation is to extend to at least 300 mm below the lightest waterline.

3.2.8 Except in spaces protected by an automatic sprinkler system and fully addressable fire detection system, all linings, flooring and ceilings are to be of non-combustible materials.

3.3 Protection of stairways and lifts in accommodation and service spaces for yachts of more than 500 GT

3.3.1 *(1/1/2020)*

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.

3.3.2 *(1/7/2022)*

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.

3.4 Openings in A class divisions

3.4.1 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.

3.4.2 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 3,5º 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 1 m 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:

   - the control system is to be able to operate the door at a temperature of at least 200ºC for at least 60 min, 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.

3.4.3 Where A 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.

3.5 Openings in B class divisions

3.5.1 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 0,05m^2. 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 non-combustible or of substantial construction.

3.5.2 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.

3.6 Windows and portlights

3.6.1 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.

3.7 Details of construction

3.7.1 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.

3.7.2 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.

3.7.3 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 *(1/7/2021)*

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.

For yachts of 500 GT and over, the above insulation is to be A-60 for the entire length of the duct within the accommodation spaces.

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 free-standing fuel tanks are installed are to be ventilated independently of systems serving other spaces.

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.

SECTION 4 DETECTION AND ALARM

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 to be adopted for yachts less than 500 GT

2.1

2.1.1 *(1/1/2020)*

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 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.

Manually operated call points shall be placed to ensure a readily accessible means of notification.

2.1.2 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.

3 Fixed fire detection and fire alarm systems to be adopted for yachts of 500 GT and over

3.1 General

3.1.1 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.

3.1.2 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.

3.2 Fire detection and alarms

3.2.1 Manually operated call points complying with the requirements of SOLAS II-2/7 and the IMO FSS Code, Chapter 9 are to be installed.

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 *(1/1/2020)*

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.

3 Means of escape from machinery spaces

3.1

3.1.1

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.

4 Dispensation from two means of escape

4.1

4.1.1 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.

5 Escape route arrangement

5.1

5.1.1 Concealed escapes and escape routes are to be clearly marked to ensure ready exit. 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.

5.1.2 Lifts are not considered as forming a means of escape.

5.1.3 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, and for yachts less than 500 GT, 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).

5.1.4 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.

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 Tasneef 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 *(15/8/2017)*

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.

3 Electrical equipment and alarm systems

3.1

3.1.1 *(15/8/2017)*

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 *(15/8/2017)*

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 ship'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.

Note 1: EN Publication 50194-2 only apply to yachts with length L_{LL} not exceeding 24 m.

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/m^2 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 Tasneef 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 *(15/8/2017)*

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.

SECTION 7 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 *(1/1/2019)*

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 See the requirements of item [4]
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
10	Fire extinguisher in sleeping accommodation	1 portable fire extinguisher type E-II for each accommodation space occupied by more than 4 persons 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 CO_2 type are not permitted in accommodation spaces

Num	Appliances	Number and specifications
11	Fire extinguishers in corridors	1 portable fire extinguisher type D-II for each corridor more than 5 metres 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 CO_2 type are not permitted in corridors
12	Fireman outfit's	1 for yachts of more than 300 GT.

Table 2 : Type and medium capacity *(1/1/2019)*

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 For yachts less than 500 GT the second fire pump may be portable.

2.1.4 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 amidships.

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.

2.4 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 vessel.

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 an oil fired boiler, fuel oil settling tank or fuel oil unit.

3.1.2 *(1/1/2016)*

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.

SECTION 8 FIRE CONTROL PLAN

1 Fire control plan content

1.1 General requirements

1.1.1 The fire control plan is to 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, [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 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 fire-fighting 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).

SECTION 10 REFUEL STATION LOCATED INSIDE A GARAGE CONTAINING VEHICLES OR CRAFTS WITH FUEL IN THEIR TANKS

1 General

1.1

1.1.1 *(1/1/2021)*

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 directly 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.

In the garage close before the flexible hose of the refueling system inside the garage 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.

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 dedicated tank is to be located below the refueling area.

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.

Gun, pump and e other fittings (e.g. litre counter…) have to be in accordance with a recognized international standard.

An additional fire extinguisher type EII is to be located close to the refueling area.

APPENDIX 1 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 *(1/1/2016)*

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 2 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 Tasneef

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

Diameter	Diameter	CO_2 quantity, in kg	
Nominal D_N (mm)	External d_e (mm)	Machinery and boiler 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
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 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 ships 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.

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, Ch1 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 mm^2. 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 CO_2 collecting main, or into a proper exhaust pipe leading to the open, Tasneef may waive the requirement for mechanical ventilation of the CO_2 room; failing this, the discharge of such safety device is to be equipped with a jet breaker.

3.4.3 *(1/1/2019)*

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 *(1/1/2019)*

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 prealarm 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 Tasneef

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 Tasneef
- 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 Tasneef
- 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 Tasneef 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 "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 Tasneef 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 Tasneef 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 Tasneef