ACS (Asia Classification Society)

Rules for

Classification of Vessels

(2014)

Part 4

Machinery, Electricity, Automation and Fire Protection

Rules for Classification of Vessels

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Part 4 Machinery Electricity Automation and Fire Protection

Chapter 1 Machinery Installations

Section 1 General Requirements and Guidance

1 Scope and Application

1.1 The Rules for Machinery Installations apply to the propulsion installations of ships classed by ACS, including all the auxiliary machinery and equipment necessary for the operation and safety of the ship.

They also apply to machinery which ACS is to confirm as being equivalent to classed machinery.

1.2 Apart from the machinery and equipment detailed below, the Rules are also individually applicable to other machinery and equipment where this is necessary to the safety of the ship or its cargo.

1.3 Designs which deviate from the Rules may be approved provided that such designs have been examined by ACS for suitability and have been recognized as equivalent.

1.4 Machinery installations which have been developed on novel principles and/or which have not yet been sufficiently tested in shipboard service require ACS's special approval.

1.5 In the instances mentioned in 1.3 and 1.4, ACS is entitled to require additional documentation to be submitted and special trials to be carried out.

1.6 In addition to the Rules, ACS reserve the right to impose further requirements in respect of all types of machinery where this is unavoidable due to new findings or operational experience, or ACS may permit deviations from the Rules where these are specially warranted.

1.7 Passenger ships having a length of 120 m or more or having three or more main vertical fire zones shall also comply with MSC.216(82) and MSC.1/ Circ.1214. Applicable to passenger ships with keel laying on or after 1 July 2010.

1.8 National regulations outside ACS's Rules remain unaffected.

2 Documents for Approval

2.1 Before the start of manufacture, plans showing the general arrangement of the machinery installation together with all drawings of parts and installations subject to testing, to the extent specified in the following Sections are each to be submitted to ACS. In specific cases and following prior agreement with ACS they can also be submitted in paper form in triplicate.

2.2 The drawings shall contain all the data necessary for approval. Where necessary, calculations and descriptions of the plant are to be submitted.

2.3 Once the documents submitted have been approved by ACS they are binding on the execution of the work. Any subsequent modifications require ACS's approval before being put into effect.

3 Ambient Conditions

3.1 Operating conditions, general

3.1.1 The selection, layout and arrangement of all shipboard machinery, equipment and appliances shall be such as to ensure faultless continuous operation under the ambient conditions specified in Tables 3.1 - 3.4.

3.1.2 Account is to be taken of the effects on the machinery installation of distortions of the ship's hull.

3.2 Vibrations

3.2.1 General

3.2.1.1 Machinery, equipment and hull structures are normally subjected to vibration stresses. Design, construction and installation shall in every case take account of these stresses.

The faultless long-term service of individual components shall not be endangered by vibration stresses.

ACS may consider deviations from the angles of inclination defined in Table 3.1 taking into consideration the type, size and service conditions of the ship.

3.2.1.2 For vibrations generated by an engine or other device the intensity shall not exceed defined limits. The purpose is to protect the vibration generators, the connected assemblies, peripheral equipment and hull components from additional, excessive vibration stresses liable to cause premature failures or malfunctions.

Table 3.1: Inclinations

<table>
<tr><th rowspan="3">Installations, Components</th><th colspan="4">Angle of inclination [°] [2]</th></tr>
<tr><th colspan="2">Athwartship</th><th colspan="2">Fore-and-aft</th></tr>
<tr><th>static</th><th>dynamic</th><th>static</th><th>dynamic</th></tr>
<tr><td>Main and auxiliary machinery</td><td>15</td><td>22.5</td><td>5 [4]</td><td>7.5</td></tr>
<tr><td>Ship's safety equipment, e.g. emergency power installations, Emergency fire pumps and their drives</td><td rowspan="2">22.5 [3]</td><td rowspan="2">22.5 [3]</td><td rowspan="2">10</td><td rowspan="2">10</td></tr>
<tr><td>Switchgear, electrical and electronic appliances [1] and remote control systems</td></tr>
</table>

1) Up to an angle of inclination of 45° no undesired switching operations or functional changes may occur.

2) Athwartships and fore- and aft - inclinations may occur simultaneously.

3) On ships for the carriage of liquefied gases and chemicals the emergency power supply shall also remain operational with the ship flooded to a final athwartships inclination up to a maximum of 30°.

4) Where the length of the ship exceeds 100 m, the fore-and aft static angle of inclination may be taken as 500/L degrees.

Table 3.2: Water temperature

Coolant	Temperature [°C]
Seawater	+ 32 [1]
Charge air coolant inlet to charge air cooler	+ 32 [1]

1) ACS may approve lower water temperatures for ships operating only in special geographical areas.

3.2.1.3 The following provisions relate the vibrations in the frequency range from 2 to 300 Hz. The underlying assumption is that vibrations with oscillation frequencies below 2 Hz can be regarded as rigid-body vibrations while vibrations with oscillation frequencies above 300 Hz normally occur only locally and may be interpreted as structure-borne noise. Where, in special cases, these assumptions are not valid (e.g. where the vibration is generated by a gear pump with a tooth meshing frequency in the range above 300 Hz) the following provisions are to be applied in analogous manner.

Table 3.3: Air temperature at atmospheric pressure =1000 mbar, and relative humidity = 60 %

Installations, components	Location, arrangement	Temperature range[°C]
Machinery and electrical installation [1]	in enclosed spaces	0 to 45 [2]
	on machinery components, boilers	According to specific local conditions
	in spaces, subject to higher or lower temperatures	
	on the open deck	- 25 to + 45

1) Electronic appliances shall be designed and tested to ensure trouble-free operation even at a constant air temperature of + 55 °C.

2) ACS may approve lower air temperatures for ships designed only for service in particular geographical areas.

Table 3.4: Other ambient conditions

Location	Conditions
In all spaces	Ability to withstand oil vapour and salt-laden air
	Trouble-free operation within the temperature ranges stated in Table 3.3, and with a relative humidity up to 100 % at a reference temperature of 45 °C
	Tolerance to condensation is assumed
In specially protected control rooms	80 % relative humidity at a reference temperature of 45 °C
On the open deck	Ability to withstand temporary flooding with seawater and salt-laden spray

3.2.1.4 Attention has to be paid to vibration stresses over the whole relevant operating range of the vibration generator.

Where the vibration is generated by an engine, consideration is to be extended to the whole available working speed range and, where appropriate, to the whole power range.

3.2.1.5 The procedure described in the following is largely standardized. Basically, a substitution quantity is formed for the vibration stress or the intensity of the exciter spectrum (see 3.2.2.1). This quantity is then compared with permissible or guaranteed values to check that it is admissible.

3.2.1.6 The procedure mentioned in 3.2.1.5 takes only incomplete account of the physical facts. The aim is to evaluate the true alternating stresses or alternating forces. No simple relationship exists between the actual loading and the substitution quantities: vibration amplitude vibration velocity and vibration acceleration at external parts of the frame. Nevertheless this procedure is adopted since it at present appears to be the only one which can be implemented in a reasonable way. For these reasons it is expressly pointed out that the magnitude of the substitution quantities applied in relation to the relevant limits enables no conclusion to be drawn concerning the reliability or loading of components as long as these limits are not exceeded. It is, in particular, inadmissible to compare the loading of components of different reciprocating machines by comparing the substitution quantities measured at the engine frame.

3.2.1.7 For reciprocating machinery, the following statements are only applicable for outputs over 100 kW and speeds below 3000 min-1.

3.2.2 Assessment

3.2.2.1 In assessing the vibration stresses imposed on machinery, equipment and hull structures, the vibration velocity $\hat{v}$ is generally used as a criterion for the prevailing vibration stress. The same criterion is used to evaluate the intensity of the vibration spectrum produced by a vibration exciter (3.2.1.2).

In the case of a purely sinusoidal oscillation, the effective value of the vibration velocity veff can be calculated by the formula:

$$v_{eff} = \frac{1}{\sqrt{2}}\hat{s}\omega = \frac{1}{\sqrt{2}}\hat{v} = \frac{1}{\sqrt{2}}\frac{\hat{a}}{\omega}$$

in which

$\hat{s}$: vibration displacement amplitude

$\hat{v}$: vibration velocity amplitude

V_{eff}: effective value of vibration velocity

Â: vibration acceleration amplitude

ω: angular velocity of vibration.

For any periodic oscillation with individual harmonic components 1, 2,...n, the effective value of the vibration velocity can be calculated by the formula:

$$v_{eff} = \sqrt{v_{eff1}^2 + v_{eff2}^2 + ... + v_{effn}^2}$$

in which v_{effi} is the effective value of the vibration velocity of the i-th harmonic component. Using above formula, the individual values of v_{effi} are to be calculated for each harmonic.

Depending on the prevailing conditions, the effective value of the vibration velocity is given by the first formula for purely sinusoidal oscillations or by the second formula for any periodic oscillation.

3.2.2.2 The assessment of vibration loads is generally based on areas A, B and C, which are enclosed by the boundary curves shown in Figure 3.1. The boundary curves of areas A, B, and C are indicated in Table 3.5.

If the vibration to be assessed comprises several harmonic components, the effective value according to 3.2.2.1 is to be applied. The assessment of this value is to take account of all important harmonic components in the range from 2 to 300 Hz.

3.2.2.3 Area A can be used for the assessment of all machines, equipment and appliances. Machines, equipment and appliances for use on board ship shall as a minimum requirement be designed to withstand a vibration load corresponding to the boundary curve or area A.

Otherwise, with ACS's consent, steps are to be taken (vibration damping, etc.) to reduce the actual vibration load to the permissible level.

3.2.2.4 Because they act as vibration exciters, reciprocating machines are to be separately considered. Both the vibration generated by reciprocating machines and the stresses consequently imparted to directly connected peripheral equipment (e.g. governors, exhaust gas turbochargers and lubricating oil pumps) and adjacent machines or plant (e.g. generators, transmission systems and pipes) can, for the purpose of these Rules and with due regard to the limitations stated in 3.2.1.6, be assessed using the substitution quantities presented in 3.2.2.1.

3.2.2.4.1 In every case the manufacturer of reciprocating machines has to guarantee permissible vibration loads for the important directly connected peripheral equipment. The manufacturer of the reciprocating machine is responsible to ACS for proving that the vibration loads are within the permissible limits in accordance with 3.2.3.

3.2.2.4.2 Where the vibration loads of reciprocating machines lie within the A' area, separate consideration or proofs relating to the directly connected peripheral equipment (see 3.2.2.4) are not required. The same applies to machines and plants located in close proximity to the generator (3.2.2.4).

Figure 3.1: Areas for assessment of vibration loads

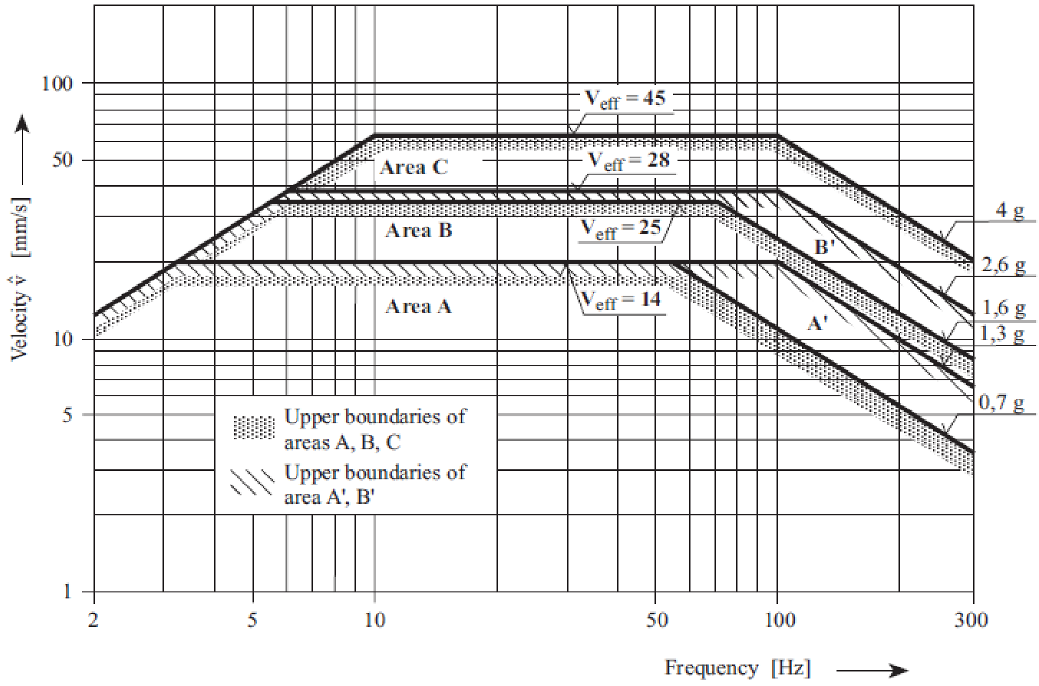


Table 3.5: Numerical definition of the area boundaries shown in Figure 3.1

Areas	A	B	C	A’	B’
$\hat{S}$ [mm]	< 1	< 1	< 1	< 1	< 1
$\hat{V}$ [mm/s]	< 20	< 35	< 63	< 20	< 40
v_{eff} [mm/s]	< 14	< 25	< 45	< 14	< 28
â [9.81m/s²]	< 0.7	< 1.6	< 4	< 1.3	< 2.6

In these circumstances directly connected peripheral appliances shall in every case be designed for at least the limit loads of area B' and machines located nearby for the limit loads of area B.

If the permissible vibration loads of individual directly connected peripheral appliances in accordance with 3.2.2.4.1 lie below the boundary curve of area B, admissibility shall be proved by measurement of the vibration load which actually occurs.

3.2.2.4.3 If the vibration loads of reciprocating machines lie outside area A' but are still within area B', it shall be proved by measurement that directly connected peripheral appliances are not loaded above the limits for area C.

In these circumstances directly connected peripheral appliances shall in every case be designed for at least the limit loads of area C, and machines located nearby for the limit loads of area B.

Proof is required that machines and appliances located in close proximity to the main exciter are not subjected to higher loads than those defined by the boundary curve of area B.

If the permissible vibration loads of individual directly connected peripheral appliances or machines in accordance with 3.2.2.4.1 lie below the stated values, admissibility shall be proved by measurement of vibration load which actually occurs.

3.2.2.4.4 If the vibration loads of reciprocating machines lie outside area B' but are still within area C, it is necessary to ensure that the vibration loads on the directly connected peripheral appliances still remain within area C. If this condition cannot be met, the important peripheral appliances are to be in accordance with 3.2.3 be demonstrably designed for the higher loads.

Suitable measures (vibration damping, etc.) are to be taken to ensure reliable prevention of excessive vibration loads on adjacent machines and appliances.

The permissible loads stated in 3.2.2.4.3 (area B or a lower value specified by the manufacturer) continue to apply to these units.

3.2.2.4.5 For directly connected peripheral appliances, ACS may approve higher values than those specified in 3.2.2.4.2 to 3.2.2.4.4 where these are guaranteed by the manufacturer of the reciprocating machine in accordance with 3.2.2.4.1 and are proved in accordance with 3.2.3.

Analogously, the same applies to adjacent machines and appliances where the relevant manufacturer guarantees higher values and provides proof of these in accordance with 3.2.3.

3.2.2.5 For appliances, equipment and components which, because of their installation in steering gear compartments or bow thruster compartments, are exposed to higher vibration stresses, the admissibility of the vibration load may, notwithstanding 3.2.2.3, be assessed according to the limits of area B. The design of such equipment shall allow for the above mentioned increased loads.

3.2.3 Proofs

3.2.3.1 Where in accordance with 3.2.2.4.1, 3.2.2.4.4 and 3.2.2.4.5 ACS is asked to approve higher vibration load values, all that is normally required for this is the binding guarantee of the admissible values by the manufacturer or the supplier.

3.2.3.2 ACS reserve the right to call for detailed proofs (calculations, design documents, measurements, etc.) in cases where this is warranted.

3.2.3.3 Type approval in accordance with ACS Guidelines is regarded as proof of admissibility of the tested vibration load.

3.2.3.4 ACS may recognize long-term troublefree operation as sufficient proof of the required reliability and operational dependability.

3.2.3.5 The manufacturer of the reciprocating machine is in every case responsible to ACS for any proof which may be required concerning the level of the vibration spectrum generated by reciprocating machinery.

3.2.4 Measurement

3.2.4.1 Proof based on measurements is normally required only for reciprocating machines with an output of more than 100 kW, where the other conditions set out in 3.2.2.4.2 – 3.2.2.4.4 are met. Where circumstances warrant this, ACS may also require proofs based on measurements for smaller outputs.

3.2.4.2 Measurements are to be performed in every case under realistic service conditions at the point of installation. During verification, the output supplied by the reciprocating machine shall be not less than 80 % of the rated value. The measurement shall cover the entire available speed range in order to facilitate the detection of any resonance phenomena.

3.2.4.3 ACS may accept proofs based on measurements which have not been performed at the point of installation (e.g. test bed runs) or at the point of installation but under different mounting conditions provided that the transferability of the results can be proved.

The results are normally regarded as transferable in the case of flexibly mounted reciprocating machines of customary design.

If the reciprocating machine is not flexibly mounted, the transferability of the results can still be acknowledged if the essential conditions for this (similar bed construction, similar installation and pipe routing, etc.) are satisfied.

3.2.4.4 The assessment of the vibration stresses affecting or generated by reciprocating machines normally relates to the location in which the vibration loads are greatest. Figure 3.2 indicates the points of measurement which are normally required for an inline piston engine. The measurement has to be performed in all three directions. In justified cases exceptions can be made to the inclusion of all the measuring points.

3.2.4.5 The measurements can be performed with mechanical manually-operated instruments provided that the instrument setting is appropriate to the measured values bearing in mind the measuring accuracy.

Directionally selective, linear sensors with a frequency range of at least 2 to 300 Hz should normally be used. Non-linear sensors can also be used provided that the measurements take account of the response characteristic.

With extremely slow-running reciprocating machines, measurements in the 0.5 to 2 Hz range may also be required. The results of such measurements within the stated range cannot be evaluated in accordance with 3.2.2.

3.2.4.6 The records of the measurements for the points at which the maximum loads occur are to be submitted to ACS together with a tabular evaluation.

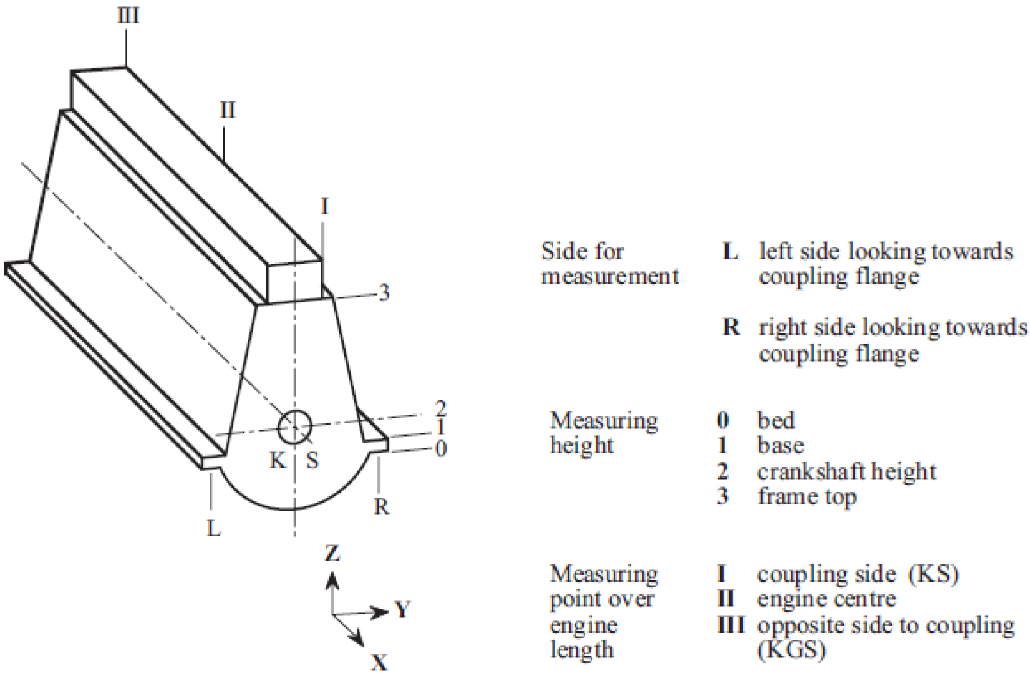


Figure 3.2: Schematic representation of in-line piston engine

4 Design and Construction of the Machinery Installation

4.1 Dimensions of components

4.1.1 All parts are to be capable of withstanding the stresses and loads peculiar to shipboard service, e.g. those due to movements of the ship, vibrations, intensified corrosive attack, temperature changes and wave impact, and shall be dimensioned in accordance with the requirements set out in the present Chapter.

In the absence of Rules governing the dimensions of parts, the recognized rules of engineering practice are to be applied.

4.1.2 Where connections exist between systems or plant items which are designed for different forces, pressures and temperatures (stresses), safety devices are to be fitted which prevent the over-stressing of the system or plant item designed for the lower design parameters. To preclude damage, such systems are to be fitted with devices affording protection against excessive pressures and temperatures and/or against overflow.

4.2 Materials

All components shall comply with the ACS Rules Part 2 – Materials and Welding.

4.3 Welding

The fabrication of welded components, the approval of companies and the testing of welders are subject to the ACS Rules Part 2– Materials and Welding.

4.4. Tests

4.4.1 Machinery and its component parts are subject to constructional and material tests, pressure and leakage tests, and trials. All the tests prescribed in the following Sections are to be conducted under the supervision of ACS.

In the case of parts produced in series, other methods of testing can be agreed with ACS instead of the tests prescribed, provided that the former are recognized as equivalent by ACS.

4.4.2 ACS reserves the right, where necessary, to increase the scope of the tests and also to subject to testing those parts which are not expressly required to be tested according to the Rules.

4.4.3 Components subject to mandatory testing are to be replaced with tested parts.

4.4.4 After installation on board of the main and auxiliary machinery, the operational functioning of the machinery including the associated ancillary equipment is to be verified. All safety equipment is to be tested, unless adequate testing has already been performed at the manufacturer's works in the presence of ACS's Representative.

In addition, the entire machinery installation is to be tested during sea trials, as far as possible under the intended service conditions.

4.4.5 For the requirements during sea trials see section 14.

4.5 Corrosion protection

Parts which are exposed to corrosion are to be safeguarded by being manufactured of corrosion-resistant materials or provided with effective corrosion protection.

4.6 Availability of machinery

4.6.1 Ship's machinery is to be so arranged and equipped that it can be brought into operation from the "dead ship" condition with the means available on board.

The "dead ship" condition means that the entire machinery installation including the electrical power supply is out of operation and auxiliary sources of energy such as starting air, battery-supplied starting current, etc. are not available for restoring the ship's electrical system, restarting auxiliary operation and bringing the propulsion installation back into operation.

To overcome the "dead ship" condition use may be made of an emergency generator set provided that it is ensured that the electrical power for emergency services is available at all times.

4.6.2 In case of "dead-ship" condition it is to be ensured that it will be possible for the propulsion system and all necessary auxiliary machinery to be restarted within a period of 30 minutes (see Ch. 2, Sec. 2).

4.7 Control and regulating

4.7.1 Machinery is to be so equipped that it can be controlled in accordance with operating requirements in such a way that the service conditions prescribed by the manufacturer can be met.

4.7.1.1 For the control equipment of main engine and system essential for operation, (see Ch. 3, Sec. 3).

4.7.2 In the event of failure or fluctuations of the supply of electrical, pneumatic or hydraulic power to regulating and control systems, or in case of a break in a regulating or control circuit, steps are to be taken to ensure that:

- the appliances remain at their present operational setting or, if necessary, are changed to a setting which will have the minimum adverse effect on operation (fail-safe conditions)
- the power output or engine speed of the machinery being controlled or governed is not increased and
- no unintentional start-up sequences are initiated.

4.7.3 Manual operation

Every functionally important, automatically or remote controlled system shall also be capable of manual operation.

4.8 Propulsion plant

4.8.1 Manoeuvring equipment

Every engine control platform is to be equipped in such a way that

- the propulsion plant can be adjusted to any setting
- the direction of propulsion can be reversed and
- the propulsion unit or the propeller shaft can be stopped.

4.8.2 Remote controls

The remote control of the propulsion plant from the bridge is subject to the ACS Rules for Automation , chapter 3.

4.8.3 Multiple-shaft and multi-engine systems

Steps are to be taken to ensure that in the event of the failure of a propulsion engine, operation can be maintained with the other engines, where appropriate by a simple change-over system.

For multiple-shaft systems, each shaft is to be provided with a locking device by means of which dragging of the shaft can be prevented.

4.9 Turning appliances

4.9.1 Machinery is to be equipped with suitable and adequately dimensioned turning appliances.

4.9.2 The turning appliances are to be of the self locking type. Electric motors are to be fitted with suitable retaining brakes.

4.9.3 An automatic interlocking device is to be provided to ensure that the propulsion and auxiliary prime movers cannot start up while the turning gear is engaged. In case of manual turning installations warning devices may be provided alternatively.

4.10 Operating and maintenance instructions

4.10.1 Manufacturers of machinery, boilers and auxiliary equipment shall supply a sufficient number of operating and maintenance notices and manuals together with the equipment.

In addition, an easily legible board is to be mounted on boiler operating platforms giving the most important operating instructions for boilers and oil-firing equipment.

4.11 Markings, identification of machinery parts

In order to avoid unnecessary operating and switching errors, all parts of the machinery whose function is not immediately apparent are to be adequately marked and labelled.

4.12 Fuels

4.12.1 The flash point (Based, up to 60 °C, on determination of the flash point in a closed crucible (cup test)) of liquid fuels for the operation of boilers and diesel engines shall not be lower than 60 °C.

For emergency generating sets, however, use may be made of fuels with a flash point of ≥43 °C.

4.12.2 In exceptional cases, for ships intended for operation in limited geographical areas or where special precautions subject to ACS's approval are taken, fuels with flash points between 43 °C and 60 °C may also be used. This is conditional upon the requirement that the temperatures of the spaces in which fuels are stored or used shall invariably be 10 °C below the flash point.

4.12.3 The use of gaseous fuels taken from the cargo is subject to ACS Rules for Liquefied Gas Carriers.

4.12.4 For the use of gas as fuel, which is not taken from the cargo, requirements for the use of Gas as Fuel for Ships are to be observed.

5 Engine and Boiler Room Equipment

5.1 Operating and monitoring equipment

5.1.1 Instruments, warning and indicating systems and operating appliances are to be clearly displayed and conveniently sited. Absence of dazzle, particularly on the bridge, is to be ensured.

Operating and monitoring equipment is to be grouped in such a way as to facilitate easy supervision and control of all important parts of the installation.

The following requirements are to be observed when installing systems and equipment:

- protection against humidity and the effects of dirt
- avoidance of excessive temperature variations
- adequate ventilation

In consoles and cabinets containing electrical or hydraulic equipment or lines carrying steam or water the electrical gear is to be protected from damage due to leakage.

Redundant ventilation systems are to be provided for air-conditioned machinery and control rooms.

5.1.2 Pressure gauges

The scales of pressure gauges are to be dimensioned up to the specified test pressure. The maximum permitted operating pressures are to be marked on the pressure gauges for boilers, pressure vessels and in systems protected by safety valves.

Pressure gauges are to be installed in such a way that they can be isolated.

Lines leading to pressure gauges are to be installed in such a way that the readings cannot be affected by liquid heads and hydraulic hammer.

5.2 Accessibility of machinery and boilers

5.2.1 Machinery- and boiler installations and apparatus are to be accessible for operation and maintenance.

5.2.2 In the layout of machinery spaces (design of foundation structures, laying of pipelines and cable conduits, etc.) and the design of machinery and equipment (mountings for filters, coolers, etc.), 5.2.1 is to be complied with.

5.3 Engine control rooms

Engine control rooms are to be provided with at least two exits, one of which can also be used as an escape route.

5.4 Lighting

All operating spaces are to be adequately lit to ensure that control and monitoring instruments can be easily read. In this connection see ACS Rules for Electrical Installations, chapter 2.

5.5 Bilge wells/bilges

5.5.1 Bilge wells and bilges are to be readily accessible, easy to clean and either easily visible or adequately lit.

5.5.2 Bilges beneath electrical machines are to be so designed as to prevent bilge water from penetrating into the machinery at all angles of inclination and movements of the ship in service.

5.5.3 For the following spaces bilge level monitoring is to be provided and limit values being exceeded are to be indicated at a permanently manned alarm point:

- Unmanned machinery rooms of category "A" are to be equipped with at least 2 indicators for bilge level monitoring.
- Other unmanned machinery rooms, such as bow thruster or steering gear compartments arranged below the load waterline are irrespective of Class Notation AUT to be equipped at least with one indicator for bilge level monitoring.

5.6 Ventilation

The machinery ventilation is to be designed under consideration of ambient conditions as mentioned in Table 3.3.

The ventilation coaming of machinery spaces shall be arranged such that no weathertight closures need to be fitted in accordance with LLC 1966 as amended 1988 Reg. 19. Machinery spaces are those spaces defined in SOLAS II-1 Reg. 3.16.

5.7 Noise abatement

In compliance with the relevant national regulations, care is to be taken to ensure that operation of the ship is not unacceptably impaired by engine noise.

6 Safety Equipment and Protective Measures

Machinery is to be installed and safeguarded in such a way that the risk of accidents is largely ruled out.

Besides of national regulations particular attention is to be paid to the following:

6.1 Moving parts, flywheels, chain and belt drives, linkages and other components which could constitute an accident hazard for the operating personnel are to be fitted with guards to prevent contact. The same applies to hot machine parts, pipes and walls for which no thermal insulation is provided, e.g. pressure lines to air compressors.

6.2 When using hand cranks for starting internal combustion engines, steps are to be taken to ensure that the crank disengages automatically when the engines start.

Dead-Man's circuits are to be provided for rotating equipment.

6.3 Blowdown and drainage facilities are to be designed in such a way that the discharged medium can be safely drained off.

6.4 In operating spaces, anti-skid floor plates and floor-coverings are to be used.

6.5 Service gangways, operating platforms, stairways and other areas open to access during operation are to be safeguarded by guard rails. The outside edges of platforms and floor areas are to be fitted with coamings unless some other means is adopted to prevent persons and objects from sliding off.

6.6 Glass water level gauges for steam boilers are to be equipped with protection devices.

Devices for blowing through water level gauges shall be capable of safe operation and observation.

6.7 Safety valves nd shutoffs are to be capable of safe operation. Fixed steps, stairs or platforms are to be fitted where necessary.

6.8 Safety valves are to be installed to prevent the occurrence of excessive operating pressures.

6.9 Steam and feedwater lines, exhaust gas ducts, boilers and other equipment and pipelines carrying steam or hot water are to be effectively insulated.

Insulating materials are to be incombustible. Points at which combustible liquids or moisture can penetrate into the insulation are to be suitably protected, e.g. by means of shielding.

7 Communication and Signalling Equipment

7.1 Voice communication

Means of voice communication are to be provided between the ship's manoeuvring station, the engine room and the steering gear compartment, and these means shall allow fully satisfactory intercommunication independent of the main shipboard power supply under all operating conditions.

7.2 Engineer alarm

From the engine room or the engine control room it shall be possible to activate an alarm in the engineers' living quarters.

7.3 Engine telegraph

Machinery operated from the engine room is to be equipped with a telegraph.

In the case of multiple-shaft installations, a telegraph shall be provided for each unit.

Local control stations are to be equipped with an emergency telegraph.

7.4 Shaft revolution indicator

The speed and direction of rotation of the propeller shafts are to be indicated on the bridge and in the engine room. In the case of small propulsion units, the indicator may be dispensed with.

Barred speed ranges are to be marked on the shaft revolution indicators.

7.5 Design of communication and signaling equipment

Reversing, command transmission and operating controls, etc. are to be grouped together at a convenient point on the control platform.

The current status, "Ahead" or "Astern", of the reversing control is to be clearly indicated on the propulsion plant control platform.

Signalling devices are to be clearly perceptible from all parts of the engine room when the machinery is in full operation.

For details of the design of electrically operated command transmission, signalling and alarm systems, see ACS Rules for Electrical Installations chapter 2 and Automation chapter 3.

8 Essential Equipment

8.1 Essential for ship operation are all main propulsion plants.

8.2 Essential (operationally important) are the following auxiliary machinery and plants, which:

- are necessary for propulsion and manoeuvrability of the ship
- are required for maintaining ship safety
- serve the safety of human life as well as
- equipment according to special Characters of Classification and Class Notations

8.3 Essential auxiliary machinery and plants are comprising e.g.:

- generator units
- steering gear plant
- fuel oil supply units
- lubricating oil pumps
- cooling water/cooling media pumps
- starting and control air compressor
- starting installations for auxiliary and main engines
- charging air blowers
- exhaust gas turbochargers

- controllable pitch propeller installation
- azimuth drives
- engine room ventilation fans
- steam, hot and warm water generation plants
- thermal oil systems
- oil firing equipment
- pressure vessels and heat exchangers in essential systems
- hydraulic pumps
- fuel oil treatment units
- fuel oil transfer pumps
- lubrication oil treatment units
- bilge and ballast pumps
- heeling compensation systems
- fire pumps and fire fighting equipment
- anchor windlass
- transverse thrusters
- ventilation fans for hazardous areas
- turning gears for main engines
- bow and stern ramps as well as shell openings
- bulkhead door closing equipment
- boiler feed water pumps

8.4 For ships with equipment according to special Characters of Classification and Notations certain type-specific plants may be classed as essential equipment.

Section 2 Internal Combustion Engines and Air Compressors

1 General

1.1 Scope

The requirements contained in this Section apply to internal combustion engines used as main propulsion units and auxiliary units (including emergency units) as well as to air compressors.

For the purpose of these requirements, internal combustion engines are:

– diesel engines, fuelled with liquid fuel oil

– dual-fuel engines, fuelled with liquid fuel oil and/or gaseous fuel

– gas engines, fuelled with gaseous fuel

Requirements for dual-fuel engines and gas engines are specified in 15.

1.2 Ambient conditions

In determining the power of all engines used on board ships with an unlimited range of service, the following ambient conditions are to be used:

Barometric pressure	1000	mbar
Inlet air temperature	45	°C
Relative humidity of air	60	%
Seawater temperature	32	°C

The defined seawater temperature has especially to be considered as inlet temperature to coolers for charge air coolant operating with seawater.

1.3 Rated power

1.3.1 Diesel engines are to be designed such that their rated power when running at rated speed according to the definitions of the engine manufacturer at ambient conditions as defined in 1.2. can be delivered as a continuous power. Diesel engines are to be capable of operating continuously within power range (1) in Figure 1.1 and intermittently in power range (2). The extent of the power ranges is to be specified by the engine manufacturer.

1.3.2 Continuous power is to be understood as the standard service power which an engine is capable of delivering continuously, provided that the maintenance prescribed by the engine manufacturer is carried out in the maintenance intervals stated by the engine manufacturer.

1.3.3 The rated power is to be specified in a way that an overload power of 110 % of the rated power can be demonstrated at the corresponding speed for an uninterrupted period of 1 hour. Deviations from the overload power value require the agreement of ACS.

1.3.4 After running on the test bed, the fuel delivery system of main engines is to be so adjusted that after installation on board overload power cannot be delivered. The limitation of the fuel delivery system has to be secured permanently.

1.3.5 Subject to the prescribed conditions, diesel engines driving electrical generators are to be capable of overload operation even after installation on board.

1.3.6 Subject to the approval of ACS, diesel engines for special vessels and special applications may be designed for a continuous power (fuel stop power) which cannot be exceeded.

1.3.7 For main engines, a power diagram (Figure 1.1) is to be prepared showing the power ranges within which the engine is able to operate continuously and for short periods under service conditions.

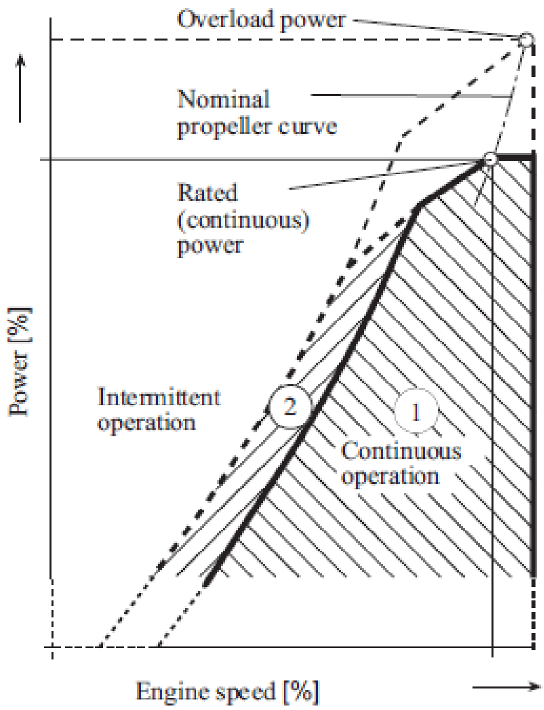


Figure 1.1: Example of a power diagram

1.4 Fuels

1.4.1 The use of liquid fuels is subject to the requirements contained in sub-section 4.12 of section 1.

1.4.2 The use of gaseous fuels is subject to the requirements in the ACS Rules for Liquefied Gas Carriers .

1.4.3 Regarding the use of low sulphur fuel the engine manufacturers recommendations with respect to e.g. fuel change-over process, lubricity, viscosity and compatibility are to be observed.

1.5 Accessibility of engines

Engines are to be so arranged in the engine room that all the assembly holes and inspection ports provided by the engine manufacturer for inspections and maintenance are accessible. A change of components, as far as practicable on board, shall be possible. Requirements related to space and construction have to be considered for the installation of the engines.

1.6 Electronic components and systems

1.6.1 For electronic components and systems which are necessary for the control of internal combustion engines the following items have to be observed:

1.6.2 Electronic components and systems have to be type approved according to ACS Requirements for Electrical / Electronic Equipment and Systems.

1.6.3 For computer systems, the ACS Rules for Electrical Installations has to be observed.

1.6.4 For main propulsion engines one failure of an electronic control system shall not result in a total loss or sudden change of the propulsion power. In individual cases, ACS may approve other failure conditions, whereby it is ensured that no increase of ship's speed occurs.

1.6.5 The non-critical behaviour in case of a failure of an electronic control system has to be proven by a structured analysis, which has to be provided by the system's manufacturer. This investigation shall include the effects on persons, environment and technical condition.

1.6.6 Where the electronic control system incorporates a speed control, 6.1.3 and the ACS Rules for Electrical Installations chapter 2 have to be observed.

1.7 Local control station

1.7.1 For the local control station, 9 has to be observed.

1.7.2 The indicators named in 9 shall be realized in such a way that one failure can only affect a single indicator. Where these indicators are an integral part of an electronic control system, means shall be taken to maintain these indications in case of failure of such a system.

1.7.3 Where these indicators are realized electrically, the power supply of the instruments and of the electronic system has to be realized in such a way to ensure the behaviour stated in 1.7.2.

2 Documents for Approval

2.1 General

For each engine type the documents listed in Table 2.1 shall, wherever applicable, be submitted to ACS by the engine manufacturer. In specific cases and following prior agreement with ACS they can also be submitted in paper form in triplicate. Where considered necessary, ACS may request further documents to be submitted.

This also applies to the documentation of design changes according to 2.4.

2.2 Engines manufactured under license

For each engine type manufactured under licence, the licensee shall submit to ACS Head Office for approval, as a minimum requirement, the following documents:

– comparison of all the drawings and documents as per Table 2.1 - where applicable – indicating the relevant drawings used by the licensee and the licensor

- all drawings of modified components, if available, as per Table 2.1 together with the licensor's declaration of consent to the modifications
- a complete set of drawings shall be put at the disposal of the local inspection office of ACS as a basis for the performance of tests and inspections

2.3 Definition of a diesel engine type

The type specification of an internal combustion engine is defined by the following data:

- manufacturer's type designation
- cylinder bore
- stroke
- method of injection (direct, indirect)
- valve and injection operation (by cams or electronically controlled)
- fuels which can be used (liquid, dual-fuel, gaseous)
- working cycle (4-stroke, 2-stroke)
- method of gas exchange (naturally aspirated or supercharged)
- rated power per cylinder at rated speed as well as mean effective pressure
- method of pressure charging (pulsating pressure system or constant-pressure charging system)
- charge air cooling system
- cylinder arrangement (in-line, Vee)

Table 2.1: Documents for approval

Ser. No.	A/R	Description	Quantity	Remarks (see below)
1	R	Detail required when applying for approval of an internal combustion engines	3	
2	R	Engine transverse cross-section	3	
3	R	Engine longitudinal section	3	
4		Bedplate and crankcase		
	R	- cast	1	
	A	- welded, with welding details and instruction	3	9
5	R	Thrust bearing assembly	3	3
6		Thrust bearing bedplate		
	R	-cast	1	
	A	- welded, with welding detail and instructions	3	9
7		Frame/frame box		
	R	- cast	1	1
	A	- welded, with welding details and instructions	3	1,9
8	R	Tie rod	1	
9	R	Cylinder cover/ head, assembly	1	
10	R	Cylinder liner	1	
11	A	Crankshaft for each number of cylinder, with data sheets for calculation of	3	
12	A	crankshafts	3	
13	A	Crankshaft assembly, for each number of cylinders	3	
14	A	Thrust shaft of intermediate shaft (if integral with engines)	3	
15	R	Shaft coupling bolts	3	
16	R	Counterweights including fastening bolts	3	
17	R	Connecting rod, details	3	
18	R	Connection rod, assembly	3	2
19	R	Crosshead assembly	3	2
20	R	Piston rod assembly	1	
21	R	Piston assembly	1	
22	A	Camshaft drive, assembly		
		Material specifications of main parts with information on non-destructive	3	8
23	R	material tests and pressure tests	3	
24	A	Arrangement of foundation (for main engines only)	3	6
25	A	Schematic layout or other equivalent documents of starting air system	3	6
26	A	Schematic layout or other equivalent documents of fuel oil system	3	6
27	A	Schematic layout or other equivalent documents of lubricating oil system	3	6
28	A	Schematic layout or other equivalent documents of cooling water system	3	6
29	A	Schematic diagram of engine control and safety system	1	
30	R	Schematic diagram of electronic components and systems	1	
31	A	Shielding and insulation of exhaust pipes, assembly	3	4
32	A	Shielding of high-pressure fuel pipes, assembly	3	5
33	R	Arrangement of crankcase explosion relief valves	1	7
34	A	Operation and service manuals	3	
35	A	Schematic layout or other equivalent documents of hydraulic system on the	1	
36	A	engine	3	10
37	A	Type test program and type test report	3	
38	A	High pressure parts for fuel oil injection system	3	6
		Oil mist detection, monitoring and alarm system		
		Schematic layout or other equivalent documents of exhaust and charging air system		

1) only for one cylinder.

2) only necessary if sufficient details are not shown on the transverse cross section and longitudinal section.

3) if integral with engine and not integrated in the bedplate.

4) for all engines.

5) only for engines with a bore > 200 mm, or a crankcase volume ≥ 0.6 m3

6) and the system, where this is supplied by the engine manufacturer. If engines incorporate electronic control systems a failure mode and effect analysis is to be submitted to demonstrate that failure of an electronic control system will not result in the loss of essential services for the operation of the engine and that operation of the engines will not be lost or degraded beyond acceptable performance criteria of the engine.

7) operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.

8) for comparison with ACS requirements for material, NDT and pressure testing as applicable.

9) The weld procedure specification is to include details of pre and post weld heat treatment, welding consumables and fit-up conditions.

10) The documentation has to contain specifications of pressures, pipe dimensions and materials.

A for approval; R for reference

2.4 Design modifications

Following initial approval of an engine type by ACS, only those documents listed in Table 2.1 require to be resubmitted for examination which embody important design modifications.

2.5 Approval of engine components

The approval of exhaust gas turbochargers, heat exchangers, engine-driven pumps, etc. is to be requested from ACS by the respective manufacturers.

3 Crankshaft Calculation

3.1 Design methods

3.1.1 Crankshafts are to be designed to withstand the stresses occurring when the engine runs at rated power and the documentation has to be submitted for approval. Calculations are to be based on the Guidelines for the Calculation of Crankshafts for Internal Combustion Engines. Other internationally accepted methods of calculation may be considered by the society.

3.1.2 Outside the end bearings, crankshafts designed according to the Guidelines specified in 3.1.1 may be adapted to the diameter of the adjoining shaft, d, by a generous fillet r, ($r \geq 0.06d$) or a taper.

3.1.3 Design methods for application to crankshafts of special construction and to the crankshafts of engines of special type are to be agreed with ACS.

3.2 Shrink joints of built-up crankshafts

The shrink joints of built-up crankshafts are to be designed in accordance with the ACS Guidelines for the Calculation of Crankshafts for Internal Combustion Engines or other internationally accepted methods.

3.3 Screw joints

3.3.1 Split crankshafts

Only fitted bolts may be used for assembling split crankshafts.

3.2 Power-end flange couplings

The bolts used to connect power-end flange couplings are normally to be designed as fitted bolts in accordance with requirements.

If the use of fitted bolts is not feasible, ACS may agree to the use of an equivalent frictional resistance transmission. In these cases the corresponding calculations are to be submitted for approval.

3.4 Torsional vibration, critical speeds. Section 10 applies.

4 Materials

4.1 Approved materials

4.1.1 The mechanical characteristics of materials used for the components of diesel engines shall conform to ACS Rules for Materials and welding, Part II.

The materials approved for the various components are shown in Table 4.2 together with the minimum required characteristics and material Certificates.

4.1.2 Materials with properties deviating from the Rules specified may be used only with ACS's special approval. ACS requires proof of the suitability of such materials.

4.2 Testing of materials

4.2.1 In the case of individually produced engines, the following parts are to be subjected to material tests in the presence of ACS's representative.

1. Crankshaft

2. Crankshaft coupling flange for main power transmission (if not forged to crankshaft)

3. Crankshaft coupling bolts

4. Pistons or piston crowns made of steel, cast steel or nodular cast iron

5. Piston rods

6. Connecting rods including the associated bearing covers

7. Crossheads

8. Cylinder liners made of steel or cast steel

9. Cylinder covers made of steel or cast steel

10. Welded bedplates:

- plates and bearing transverse girders made of forged or cast steel

11. Welded frames and crankcases
12. Welded entablatures
13. Tie rods
14. Bolts and studs for:
    - cylinder covers
    - crossheads
    - main bearings
    - connecting rod bearings
15. Camshaft drive gear wheels and chain wheels made of steel or cast steel.

4.2.1.1 Material tests are to be performed in accordance with Table 4.1.

Table 4.1: Material tests

Cylinder bore	Parts to be tested (numbered acc. to the list under 4.2.1)
≤ 300 mm	1 - 6 - 10 - 11 - 12 – 13
> 300 ≤ 400 mm	1 - 6 - 8 - 9 - 10 - 11 -12 - 13 – 14
> 400 mm	all parts

4.2.1.2 In addition, material tests are to be carried out on pipes and parts of the starting air system and other pressure systems forming part of the engine.

4.2.1.3 Materials for charge air coolers are to be supplied with Manufacturer Test Reports.

4.2.2 In the case of individually manufactured engines, non-destructive material tests are to be performed on the parts listed below in accordance with Tables 4.3 and 4.4:

1. Steel castings for bedplates, e.g. bearing transverse girders, including their welded joints
2. Solid forged crankshafts
3. Cast, rolled or forged parts of fully built crankshafts
4. Cast or forged parts of semi-built crankshafts
5. Connecting rods
6. Piston rods
7. Piston crowns of steel or cast steel
8. Tie rods (at each thread over a distance corresponding to twice the threaded length)
9. Bolts which are subjected to alternating loads, e.g.:
    - main bearing bolts
    - connecting rod bolts
    - crosshead bearing bolts
    - cylinder cover bolts

10. Cylinder covers made of steel or cast steel

11. Camshaft drive gear wheels made of steel or cast steel.

4.2.2.1 Magnetic particle or dye penetrant tests are to be performed in accordance with Table4.3 at those points, to be agreed between ACS's Surveyor and the manufacturer, where experience shows that defects are liable to occur:

4.2.2.2 Ultrasonic tests are to be carried out by the manufacturer in accordance with Table 4.4, and the corresponding manufacturer's Certificates are to be submitted.

4.2.2.3 Welded seams of important engine components may be required to be subjected to approved methods of testing.

4.2.2.4 Where there is reason to doubt the faultless quality of any engine component, non-destructive testing by approved methods may be required in addition to the tests mentioned above.

4.2.3 Crankshafts welded together from forged or cast parts are subject to ACS's special approval. Both the manufacturers and the welding process shall be approved. The materials and the welds are to be tested.

Table 4.2: Approved materials and type of test certificate

Approved materials	Components	Test certificate † A	B	C
Forged steel $R_m \geq 360$ N/mm^2	Crankshafts	X	-	-
	Connecting rods Pistons rods Crossheads Pistons and piston crowns Cylinder covers/heads Camshaft drive wheels	X X[3] X[3] X[3] X[3] X[3]	- X[4] X[4] X[4] - X[4]	- - - - - -
Rolled or forged steel rounds $R_m \geq$ 360 N/mm^2	Tie rods Bolts and studs	X X[1]	- X[2]	- -
Special grade cast steel $R_m \geq 440$ N/mm^2 and Special grade forged steel $R_m \geq$ 440 N/mm^2	Throws and webs of built-up crankshafts	X	-	-
Cast steel	Bearing transverse girders (weldable) Pistons and piston crowns Cylinder covers/heads Camshaft drive wheels	X X[3] X[1] X[3]	- X[4] X[2] X[4]	- - - -
Nodular cast iron, preferably ferritic grades $R_m \geq 370$ N/mm^2	Engine blocks Bedplates Cylinder blocks Pistons and piston crowns Cylinder covers/heads Flywheels Valve bodies	- - - X[3] - - -	X[1] X[1] X[1] X[4] X[1] X[1] X[1]	- - - - - - -
Lamellar cast iron Rm ≥ 200 N/mm^2	Engine blocks Bedplates Cylinder blocks Cylinder liners Cylinder covers/heads Flywheels	- - - - - -	- - - - - -	X X X X X X
Shipbuilding steel, all ACS grades for plate thickness ≤ 35 mm Shipbuilding steel, ACS grade B for plate thickness > 35 mm Structural steel, unalloyed, for welded assemblies	Welded cylinder blocks Welded bedplates Welded frames Welded housings	X X X X	- - - -	- - - -

* All details refer to the ACS Rules, Part II – Materials and Welding– Metallic Materials, Steel and Iron Materials

† Test Certificates are to be issued in accordance with ACS requirements

Abbreviations:

A: ACS Material Certificate, B: Manufacturer Inspection Certificate, C: Manufacturer Test Report

1) only for cylinder bores > 300 mm

2) for cylinder bores ≤ 300 mm

3) only for cylinder bores > 400 mm

4) for cylinder bores ≤ 400 mm

Table 4.3: Magnetic particle tests

Cylinder bore	Parts to be tested (numbered acc. to the list under 4.2.2)
≤ 400 mm	1 – 2 – 3 – 4 – 5
> 400 mm	all parts

Table 4.4: Ultrasonic tests

Cylinder bore	Parts to be tested (numbered acc. to the list under 4.2.2)
≤ 400 mm	1 – 2 – 3 – 4 – 7 – 10
> 400 mm	1 – 2 – 3 – 4 – 5 – 6 – 7 – 10 – 11

Table 4.5: Pressure tests [1]

Component		Test pressure, p_p [bar] [2]
Cylinder cover, cooling water space [3]		7
Cylinder liner, over whole length of cooling water space [5]		7
Cylinder jacket, cooling water space		4, at least 1.5 $p_{e,zul}$
Exhaust valve, cooling water space		4, at least 1.5 $p_{e,zul}$
Piston, cooling water space (after assembly with piston rod, if applicable)		7
Fuel injection system	Pump body, pressure side	1.5 $p_{e,zul}$ or $p_{e,zul}$ + 300 (whichever is less)
	Valves	1.5 $p_{e,zul}$ or $p_{e,zul}$ + 300 (whichever is less)
	Pipes	1.5 $p_{e,zul}$ or $p_{e,zul}$ + 300 (whichever is less)
Hydraulic system	High pressure piping for hydraulic drive of exhaust gas valves	1.5 $p_{e,zul}$
Exhaust gas turbocharger, cooling water space		4, at least 1.5 $p_{e,zul}$
Exhaust gas line, cooling water space		4, at least 1.5 $p_{e,zul}$
Coolers, both sides [4]		4, at least 1.5 $p_{e,zul}$
Engine-driven pumps (oil, water, fuel and bilge pumps)		4, at least 1.5 $p_{e,zul}$
Starting and control air system		1.5 $p_{e,zul}$ before installation

1) In general, items are to be tested by hydraulic pressure. Where design or testing features may require modification of these test requirements, special arrangements may be agreed.

2) $p_{e,\,zul}$ [bar] = maximum allowable working pressure in the part concerned.

3) For forged steel cylinder covers test methods other than pressure testing may be accepted, e.g. suitable non-destructive examination and dimensional control exactly recorded.

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

5) For centrifugally cast cylinder liners, the pressure test can be replaced by a crack test.

5 Tests and Trials

5.1 Approval of engine manufacturer's workshops

5.1.1 Every workshop where engines are assembled and tested has to be approved by ACS when:

- the workshop is newly set up,
- a new production line is started,
- a new engine type is introduced, or
- a new production process is implemented.

5.1.2 Requirements for approval of engine manufacturer's workshops:

- The manufacturer's works are to be audited by ACS.
- Manufacturer's works have to have suitable production and testing facilities, competent staff and a quality management system, which ensures a uniform production quality of the products according to the specification.

Note:

- Manufacturing plants shall be equipped in such a way that all materials and components can be machined and manufactured to a specified standard.

  Production facilities and assembly lines, including machining units, welding processes, special tools, special devices, assembly and testing rigs as well as lifting and transportation devices shall be suitable for the type and size of engine, its components, and the purpose intended. Materials and components shall be manufactured in compliance with all production and quality instructions specified by the manufacturer and recognised by ACS.
- Suitable test bed facilities for load tests have to be provided, if required also for dynamic response testing. All liquids used for testing purposes such as fuel oil, lubrication oil and cooling water shall be suitable for the purpose intended, e.g. they shall be clean, preheated if necessary and cause no harm to engine parts.
- Trained personnel shall be available for production of parts, assembly, testing and partly dismantling for shipping, if applicable.

- Storage, reassembly and testing processes for diesel engines at shipyards shall be such that the risk of damage to the engine or its parts is minimized.
- Engine manufacturer’s workshops shall have in place a Quality Management System recognized by ACS.

5.2 Manufacturing inspections

5.2.1 In general, the manufacture of engines with ACS Classification is subject to supervision by ACS. The scope of supervision should be agreed between the manufacturer and ACS.

5.2.2 Where engine manufacturers have been approved by ACS as "Suppliers of Mass Produced Engines", these engines are to be tested in accordance with relevant ACS Guidelines for approval of Mass Produced Engines.

5.3 Pressure tests

The individual components of internal combustion engines are subject to pressure tests at the pressures specified in Table 4.5 ACS Certificates are to be issued for the results of the pressure tests.

5.4 Type Approval Testing (TAT)

5.4.1 General

Engines for installation on board ship must have been type tested by ACS. For this purpose a type approval test in accordance with 5.4.1.2 is to be performed.

5.4.1.1 Preconditions for type approval testing

Preconditions for type approval testing are that:

- the engine to be tested conforms to the specific requirements for the series and has been suitably optimized
- the inspections and measurements necessary for reliable continuous operation have been performed during works tests carried out by the engine manufacturer and ACS has been informed of the results of the major inspections
- ACS has issued the necessary approval of drawings on the basis of the documents to be submitted in accordance with sub-section 2.

5.4.1.2 Scope of type approval testing

The type approval test is subdivided into three stages, namely:

- Stage A - Internal tests

Functional tests and collection of operating values including test hours during the internal tests, which are to be presented to ACS during the type test.

- Stage B - Type test

This test is to be performed in the presence of ACS's representative.

- Stage C - Component inspection

After conclusion of the tests, major components are to be presented for inspection.

The operating hours of the engine components which are to be presented for inspection after type testing in accordance with 5.3.4, are to be stated.

5.4.2 Stage A - Internal tests

Functional tests and the collection of operating data are to be performed during the internal tests. The engine is to be operated at the load points important for the engine manufacturer and the pertaining operating values are to be recorded. The load points are to be selected according to the range of application of the engine.

For engines to be operated on heavy fuel oil suitability for this shall be proved in an appropriate form.

5.4.2.1 Normal operating conditions

The includes the load points 25%, 50%, 75%, 100% and 110 % of the rated power

a) along the nominal (theoretical) propeller curve and/or at constant speed for propulsion engines

b) at rated speed with constant governor setting for generator drive

The limit points of the permissible operating range as defined by the engine manufacturer are to be tested.

5.4.2.2 Emergency operation situations

For turbocharged engines the achievable output in case of turbocharger failure is to be determined as follows:

- engines with one turbocharger, when rotor is blocked or removed
- engines with two or more turbochargers, when the damaged turbocharger is shut off

Note:

The engine manufacturer is to state whether the achievable output is continuous. If there is a time limit, the permissible operating time is to be indicated.

5.4.3 Stage B - Type test

During the type test all the tests listed below under 5.4.3.1 to 5.4.3.3 are to be carried out in the presence of ACS's representative. The results of individual tests are to be recorded and signed by ACS's representative.

Deviations from this program, if any, require ACS's agreement.

5.4.3.1 Load points

Load points at which the engine is to be operated are to conform to the power/speed diagram in Figure 5.1.

The data to be measured and recorded when testing the engine at various load points shall include all the parameters necessary for an assessment.

The operating time per load point depends on the engine size and on the time for collection of the operating values. The measurements shall in every case only be performed after achievement of steady-state condition.

Normally, an operating time of 0.5 hour can be assumed per load point.

At 100 % output (rated power) in accordance with 5.4.3.1.1 an operating time of 2 hours is required. At least two sets of readings are to be taken at an interval of 1 hour in each case.

If an engine can continue to operate without its operational safety being affected in the event of a failure of its independent cylinder lubrication, proof of this shall be included in the type test.

5.4.3.1.1 Rated power (continuous power)

The rated power is defined as 100 % output at 100 % torque and 100 % speed (rated speed) corresponding to load point 1.

5.4.3.1.2 100 % power

The operation point 100 % output at maximum allowable speed corresponding to load point 2 has to be performed.

5.4.3.1.3 Maximum permissible torque

The maximum permissible torque normally results at 110 % output at 100 % speed corresponding to load point 3 or at maximum permissible power (normally 110 % at a speed according to the nominal propeller curve corresponding to load point 3a.

5.4.3.1.4 Minimum permissible speed for intermittent operation

The minimum permissible speed for intermittent operation has to be adjusted

- at 100 % torque corresponding to load point 4
- at 90 % torque corresponding to load point 5

5.4.3.1.5 Part-load operation

For part-load operation the operation points 75 %, 50 %, 25 % of the rated power at speeds according to the nominal propeller curve at load points 6,7 and 8 and proceeding from the nominal speed at constant governor setting have to be adjusted corresponding to load points 9,10 and 11.

5.4.3.2 Emergency operation

The maximum achievable power when operating in accordance with 5.4.2.2 has to be performed

- at speed conforming to nominal propeller curve
- with constant governor setting for rated speed

5.4.3.3 Functional tests

Functional tests are to be carried out as follows:

- ascertainment of lowest engine speed according to the nominal propeller curve
- starting tests for non-reversible engines and/or starting and reversing tests for reversible engines
- governor test

- test of the safety system particularly for overspeed, oil mist and failure of the lubricating oil system
- test of electronic components and systems according to the test program approved by ACS
- for electronically controlled diesel engines integration tests to demonstrate that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes. The scope of these tests shall be proposed by the manufacturer/licensor based on the Failure Mode and effect analysis (FMEA) required in Table 2.1 and agreed by ACS.

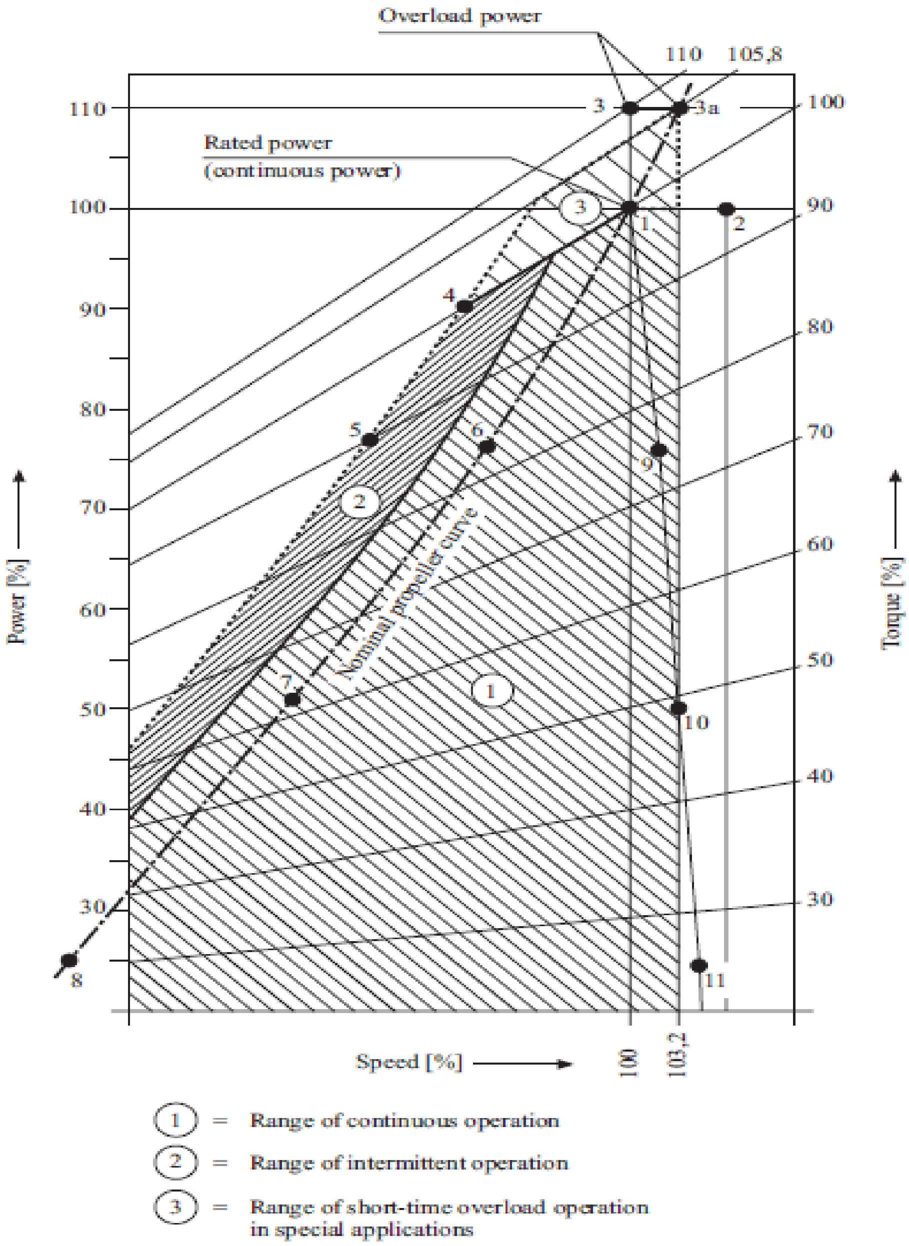


Figure 5.1: Power/speed diagram

5.4.4 Stage C - Component inspection

Immediately after the test run the components of one cylinder for in-line engines and two cylinders for V engines are to be presented for inspection as follows:

- piston, removed and dismantled
- crosshead bearing, dismantled
- crank bearing and main bearing, removed
- cylinder liner in the installed condition
- cylinder cover/ head, valves disassembled
- camshaft, camshaft drive and crankcase with opened covers

Note:

If deemed necessary by ACS's representative, further dismantling of the engine may be required.

5.4.5 Type approval test report

The results of the type approval test are to be compiled in a report which is to be submitted to ACS.

5.4.6 Type approval certificate

After successful conclusion of the test and appraisal of the required documents ACS issues a Type Approval Certificate.

The Type Approval Certificate is valid for a period of 1 year.

Validity may be renewed on application by the engine designer.

5.4.7 Type testing of mass produced engines

5.4.7.1 For engines with cylinder bores ≤ 300 mm which are to be manufactured in series and for which Approval as Mass Produced Engines is sought, the type test shall be carried out in accordance with Guidelines for Mass Produced Engines.

5.4.7.2 For the performance of the type test, the engine is to be fitted with all the prescribed items of equipment. If the engine, when on the test bed, cannot be fully equipped in accordance with the ACS Rules, the equipment may then be demonstrated on another engine of the same series.

5.4.8 Power increase

If the rated power (continuous power) of a type tested and operationally proven engine is increased by more than 10 %, a new type test is required. Approval of the power increase includes examination of the relevant drawings.

5.5 Works trials

5.5.1 Application

In general, engines are to be subjected to trials on the test bed at the manufacturer's works and under ACS's supervision. The scope of these trials shall be as specified below. Exceptions to this require the agreement of ACS.

5.5.2 Scope of works trials

During the trials the operating values corresponding to each load point are to be measured and recorded by the engine manufacturer. All the results are to be compiled in an acceptance protocol to be issued by the engine manufacturer.

In each case all measurements conducted at the various load points shall be carried out under steady operating conditions. The readings for 100 % power (rated power at rated speed) are to be taken twice at an interval of at least 30 minutes.

5.5.2.1 Main engines for direct propeller drive

The load points have to be adjusted according to a) – c), functional tests have to be performed according to d) - g).

a) 100 % power (rated power) at 100 % engine speed (rated engine speed) for at least 60 minutes after reaching the steadystate condition

b) 110 % power at 103 % rated engine speed for 30 minutes after reaching the steady-state condition

Note:

After the test bed trials the output shall normally be limited to the rated power (100 % power) so that the engine cannot be overloaded in service (see 1.3.4).

c) 90 %, 75 %, 50 % and 25 % power in accordance with the nominal propeller curve

d) starting and reversing manoeuvres

e) test of governor and independent over speed protection device

f) test of engine shutdown devices

g) test of oil mist detection or alternative system, if available

5.5.2.2 Main engines for electrical propeller drive

The test is to be performed at rated speed with a constant governor setting under conditions of:

a) 100 % power (rated power): for at least 60 minutes after reaching the steadystate condition

b) 110 % power: for 30 minutes after reaching the steady-state condition

Note:

After the test bed trials the output of engines driving generators is to be so adjusted that overload (110 %) power can be supplied in service after installation on board in such a way that the governing characteristics and the requirements of the generator protection devices can be fulfilled at all times (see 1.3.5)

c) 75 %, 50 % and 25 % power and idle run

d) start-up tests

e) test of governor and independent over speed protection device

f) test of engine shutdown devices

g) test of oil mist detection or alternative system, if available

5.5.2.3 Auxiliary driving engines and engines driving electrical generators

The scope of tests has to be performed according to 5.4.2.2.

For testing of diesel generator sets, see also ACS Rules for Electrical Installations Chapter 2.

5.5.3 Depending on the type of plant concerned, ACS reserve the right to call for a special test schedule.

5.5.4 In the case of engines driving electrical generators the rated electrical power as specified by the manufacturer is to be verified as minimum power.

5.5.5 Integration tests

For electronically controlled diesel engines integration tests shall be conducted to demonstrate that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes. The scope of these tests shall be proposed by the manufacturer/licensor based on the FMEA required in Table 2.1 and agreed by ACS.

5.5.6 Component inspection

After the test run randomly selected components shall be presented for inspection.

The crankshaft web deflection is to be checked.

5.6 Shipboard trials (dock and sea trials)

After the conclusion of the running-in programme prescribed by the engine manufacturer engines are to undergo the trials specified below.

5.6.1 Scope of trials

5.6.1.1 Main propulsion engines driving fixed pitch propellers

The tests have to be carried out as follows:

a) at rated engine speed: for at least 4 hours and at engine speed corresponding to normal continuous cruise power: for at least 2 hours

b) at 103 % rated engine speed: for 30 minutes where the engine adjustment permits (see 1.3.4)

c) determination of the minimum on-load speed

d) starting and reversing manoeuvres (see 8.2.4)

e) in reverse direction of propeller rotation at a minimum speed of 70 % rated engine speed: 10 minutes

f) testing of the monitoring and safety systems

5.6.1.2 Main propulsion engines driving controllable pitch propellers or reversing gears

5.6.1.1 applies as appropriate.

Controllable pitch propellers are to be tested with variousm propeller pitches. Where provision is made for operating in a combinator mode, the combinatory curves are to be plotted and verified by measurements.

5.6.1.3 Main engines driving generators for propulsion

The tests are to be performed at rated speed with a constant governor setting under conditions of

a) 100 % power (rated propulsion power) for at least 4 hours and at normal continuous cruise propulsion power for at least 2 hours
b) 110 % power (rated propulsion power) for 30 minutes
c) in reverse direction of propeller rotation at a minimum speed of 70 % of the nominal propeller speed for 10 minutes
d) starting manoeuvres (see 8.2.4)
e) testing of the monitoring and safety systems

Note:

Tests are to be based on the rated electrical powers of the electric propulsion motors.

5.6.1.4 Engines driving auxiliaries and electrical generators

These engines are to be subjected to an operational test for at least four hours. During the test the set concerned is required to operate at its rated power for an extended period.

It is to be demonstrated that the engine is capable of supplying 110 % of its rated power, and in the case of shipboard generating sets account shall be taken of the times needed to actuate the generator's overload protection system.

5.6.2 The suitability of main and auxiliary engines to burn residual oils or other special fuels is to be demonstrated if the machinery installation is designed to burn such fuels.

5.6.3 The scope of the shipboard trials may be extended in consideration of special operating conditions such as towing, trawling, etc.

5.6.4 Earthing

It is necessary to ensure that the limits specified for main engines by the engine manufacturers for the difference in electrical potential (Voltage) between the crankshaft/shafting and the hull are not exceeded in service. Appropriate earthing devices including limit value monitoring of the permitted voltage potential are to be provided.

6 Safety Devices

6.1 Speed control and engine protection against over speed

6.1.1 Main and auxiliary engines

6.1.1.1 Each diesel engine not used to drive an electrical generator shall be equipped with a speed governor or regulator so adjusted that the engine speed cannot exceed the rated speed by more than 15 %.

6.1.1.2 In addition to the normal governor, each main engine with a rated power of 220 kW or over which can be declutched in service or which drives a variable pitch propeller shall be fitted with an independent overspeed protection device so adjusted that the engine speed cannot exceed the rated speed by more than 20 %.

Equivalent equipment may be approved by ACS.

6.1.2 Engines driving electrical generators

6.1.2.1 Each diesel engine used to drive an electrical main or emergency generator shall be fitted with a governor which will prevent transient frequency variations in the electrical network in excess of ± 10 % of the rated frequency with a recovery time to steady state conditions not exceeding 5 seconds when the maximum electrical step load is switched on or off.

In the case when a step load equivalent to the rated output of the generator is switched off, a transient speed variation in excess of 10 % of the rated speed may be acceptable, provided this does not cause the intervention of the overspeed device as required by 6.1.2.2.

6.1.2.2 In addition to the normal governor, each diesel engine with a rated power of 220 kW or over shall be equipped with an over speed protection device independent of the normal governor which prevents the engine speed from exceeding the rated speed by more than 15 %.

6.1.2.3 The diesel engine shall be suitable and designed for the special requirements of the ship's electrical system.

Where two stage load application is required, the following procedure is to be applied: Sudden loading from no-load to 50 %, followed by the remaining 50 % of the rated generator power, duly observing the requirements of 6.1.2.1 and 6.1.2.4.

Application of the load in more than two steps (see Figure 6.1) is acceptable on condition that

- the ship's electrical system is designed for the use of such generator sets
- load application in more than two steps is considered in the design of the ship's electrical system and is approved when the drawings are reviewed
- during shipboard trials the functional tests are carried out without objections. Here the loading of the ship's electrical net while sequentially connecting essential equipment after breakdown and during recovery of the net is to be taken into account.
- the safety of the ship's electrical system in the event of parallel generator operation and failure of a generator is demonstrated.

6.1.2.4 Speeds shall be stabilized and in steady-state condition within five seconds, inside the permissible range for the permanent speed variation δr.

The steady-state condition is considered reached when the permanent speed variation does not exceed ± 1 % of the speed associated with the set power.

6.1.2.5 The characteristic curves of the governors of diesel engines of generator sets operating in parallel must not exhibit deviations larger than those specified in the ACS Rules for Electrical Installations.

6.1.2.6 Generator sets which are installed to serve stand-by circuits are to satisfy the corresponding requirements even when the engine is cold. It is assumed that the start-up and loading sequence is completed after about 30 seconds.

6.1.2.7 Emergency generator sets shall satisfy the above governor conditions also unlimited with the start-up and loading sequence having to be concluded in about 45 seconds.

6.1.2.8 The governors of the engines mentioned in 1.2 shall enable the rated speed to be adjusted over the entire power range with a maximum deviation of 5 %.

6.1.2.9 The rate of speed variation of the adjusting mechanisms shall permit satisfactory synchronization in a sufficiently short time. The speed characteristic shall be as linear as possible over the whole power range. The permanent deviation from the theoretical linearity of the speed characteristic may, in the case of generating sets intended for parallel operation, in no range exceed 1 % of the rated speed.

Notes relating to 6.1.1 and 6.1.2:

a) The rated power and the corresponding rated speed relate to the conditions under which the engines are operated in the system concerned.

b) An independent overspeed protection device means a system all of whose component parts, including the drive, function independently of the normal governor.

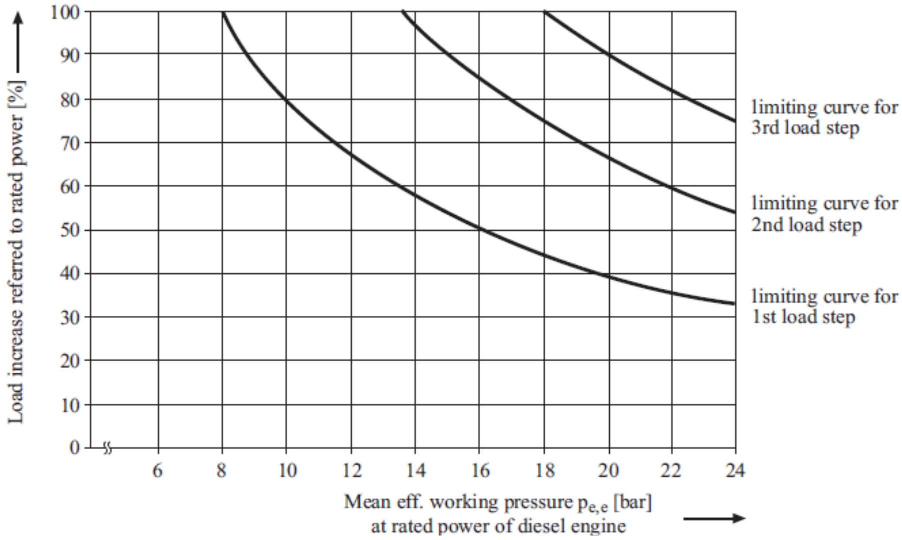


Figure 6.1: Limiting curves for loading 4-stroke diesel engines step by step from no load to rated power as function of the brake mean effective pressure

6.1.3 Use of electrical/electronic governors

6.1.3.1 The governor and the associated actuator shall, for controlling the respective engine, be suitable for the operating conditions laid down in the Construction Rules and for the requirements specified by the engine manufacturer.

The regulating conditions required for each individual application as described in 6.1.1 and 6.1.2 are to be satisfied by the governor system.

Electronic governors and the associated actuators are subject to type testing.

6.1.3.2 Requirements applying to main engines

For single engine plants it has to be ensured that in case of a failure of the governor or actuator the control of the engine can be taken over by another control device. To ensure continuous speed control or immediate resumption of control after a fault at least one of the following requirements is to be satisfied:

a) The governor system has an independent back-up system or

b) there is a redundant governor assembly for manual change-over with a separately protected power supply or

c) the engine has a manually operated fuel admission control system suitable for maneuvering.

For multiple engine propulsion plants requirements in Section 1, 4.8.3 are to be observed.

In the event of a fault in the governor system, the operating condition of the engine shall not become dangerous, that is, the engine speed and power shall not increase.

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

6.1.3.3 Requirements applying to auxiliary engines driving electrical generators

Each auxiliary engine shall be equipped with its own governor system.

In the event of a fault of components or functions which are essential for the speed control in the governor system, the speed demand output shall be set to "0" (i.e. the fuel admission in the injection pump shall be set to "0"). Alarms to indicate faults in the governor system are to be fitted.

6.1.3.4 The special conditions necessary to start operation from the dead ship condition are to be observed.

6.2 Cylinder overpressure warning device

6.2.1 All the cylinders of engines with a cylinder bore of > 230 mm are to be fitted with cylinder overpressure warning devices. The response threshold of these warning devices shall be set at not more than 40 % above the combustion pressure at the rated power.

6.2.2 A warning device may be dispensed with if it is ensured by an appropriate engine design or by control functions that an increased cylinder pressure cannot create danger.

6.3 Crankcase airing and venting

6.3.1 Crankcase airing

The airing of crankcases and any arrangement which could produce air intake within the crankcase is not allowed.

6.3.2 Crankcase venting

6.3.2.1 Where crankcase venting systems are provided, their clear opening is to be dimensioned as small as possible.

6.3.2.2 Where provision has been made for the forced extracting the lubricating oil mist, e.g. for monitoring the oil mist concentration, the vacuum in the crankcase shall not exceed 2.5 mbar.

6.3.2.3 The vent pipes and oil drain pipes of two or more engines shall not be combined. Exemptions may be approved if an interaction of the combined systems is inhibited by suitable means.

6.3.2.4 In case of two-stroke engines the lubricating oil mist from the crankcase shall not be admitted into the scavenge manifolds respectively the air intake pipes of the engine.

6.4 Crankcase safety devices

6.4.1 Relief valves

6.4.1.1 Crankcase safety devices have to be type approved in a configuration that represents the installation arrangements that will be used on an engine according to the ACS requirements.

6.4.1.2 Safety valves to safeguard against overpressure in the crankcase are to be fitted to all engines with a cylinder bore of > 200 mm or a crankcase volume of ≥ 0.6 m^3.

All separated spaces within the crankcase, e.g. gear or chain casings for camshafts or similar drives, are to be equipped with additional safety devices if the volume of these spaces exceeds 0.6 m^3.

6.4.1.3 Engines with a cylinder bore of > 200 mm and ≤ 250 mm are to be equipped with at least one relief valve at each end of the crankcase. If the crankshaft has more than 8 throws, an additional relief valve is to be fitted near the middle of the crankcase.

Engines with a cylinder bore of > 250 mm and ≤ 300 mm are to have at least one relief valve close to each alternate crank throw, with a minimum number of two.

Engines with a cylinder bore of > 300 mm are to have at least one safety valve close to each crank throw.

6.4.1.4 Each safety valve shall have a free relief area of at least 45 cm^2.

The total relief area of all safety valves fitted to an engine to safeguard against overpressure in the crankcase shall not be less than 115 cm^2 per m^3 of crankcase gross volume.

Notes relating to 6.4.1.2 and 6.4.1.3

a) In estimating the gross volume of the crankcase the volume of the enclosed fixed parts may be deducted.

b) A space communicating with the crankcase via a total free cross-sectional area of > 115 cm^2/m^3 of volume need not be considered as a separate space.

c) Each relief valve required may be replaced by not more than two relief valves of smaller cross-sectional area provided that the free cross-sectional area of each relief valve is not less than 45 cm^2.

6.4.1.5 The safety devices are to be quick acting and self closing devices to relief a crankcase of pressure at a crankcase explosion. In service they shall be oiltight when closed and have to prevent air inrush into the crankcase. The gas flow caused by the response of the safety device must be deflected, e. g. by means of a baffle plate, in such a way as not to endanger persons standing nearby. It has to be demonstrated that the baffle plate does not adversely affects the operational effectiveness of the device.

For relief valves the discs are to be made of ductile material capable of withstanding the shock load at the full open position of the valve.

Relief valves shall be fully opened at a differential pressure in the crankcase not greater than 0.2 bar.

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

6.4.1.7 Safety devices are to be provided with suitable markings that include the following information:

– name and address of manufacturer

– designation and size

– relief area

– month/year of manufacture

– approved installation orientation

6.4.1.8 Safety devices are to be provided with a manufacturer’s installation and maintenance manual that is pertinent to the size and type of device as well as on the installation on the engine. A copy of this manual is to be kept on board of the ship.

6.4.1.9 Plans showing details and arrangements of safety devices are to be submitted for approval.

6.4.2 Crankcase doors and sight holes

6.4.2.1 Crankcase doors and their fittings shall be so dimensioned as not to suffer permanent deformation due to the overpressure occurring during the response of the safety equipment.

6.4.2.2 Crankcase doors and hinged inspection ports are to be equipped with appropriate latches to effectively prevent unintended closing.

6.4.2.3 A warning notice is to be fitted either on the control stand or, preferably, on a crankcase door on each side of the engine. The warning notice is to specify that the crankcase doors or sight holes are not to be opened before a reasonable time, sufficient to permit adequate cooling after stopping the engine.

6.4.3 Oil mist detection/monitoring and alarm system (Oil mist detector)

6.4.3.1 Engines with a cylinder diameter > 300 mm or a rated power of 2250 kW and above are to be fitted with crankcase oil mist detectors or alternative systems.

For 2-stroke engines alternative methods may not replace oil mist detectors. Oil mist detectors are required to be fitted.

6.4.3.2 For multiple engine installations each engine is to be provided with a separate oil mist detector and a dedicated alarm.

6.4.3.3 Oil mist detectors are to be type approved.

The electrical part hast to be type approved according to ACS Guidelines for Test Requirements for Electrical / Electronic Equipment and Systems.

6.4.3.4 The oil mist detector is to be installed in accordance with the engine designer’s and the system manufacturer’s instructions and recommendations.

6.4.3.5 Function tests are to be performed on the engine test bed at manufacturer’s workshop and on board under the conditions of "engine at standstill" and "engine running at normal operating conditions" in accordance with test procedures to be agreed with ACS.

6.4.3.6 Alarms and shutdowns for the detector are to be in accordance with Table 9.1.

6.4.3.7 Functional failures at the devices and equipment are to be alarmed.

6.4.3.8 The oil mist detector has to indicate that the installed lens, which is used in determination of the oil mist concentration has been partly obscured to a degree that will affect the reliability of the information and alarm indication.

6.4.3.9 Where the detector includes the use of programmable electronic systems, the arrangements are in accordance with the requirements of the ACS Rules for Electrical Installations.

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

6.4.3.11 Plans of showing details and arrangements of the oil mist detector are to be submitted for approval.

The following particulars are to be included in the documentation:

- Schematic layout of engine oil mist detector showing location of engine crankcase sample points and piping arrangement together with pipe dimensions to detector/monitor.
- Evidence of study to justify the selected location of sample points and sample extraction rate (if applicable) in consideration of the crankcase arrangements and geometry and the predicted crankcase atmosphere where oil mist can accumulate.

- maintenance and test manuals
- information about type approval of the detection/ monitoring system or functional tests at the particular engine

6.4.3.12 A copy of the documentation supplied with the system such as maintenance and test manuals are to be provided on board ship.

6.4.3.13 The readings and the alarm information from the oil mist detector are to be capable of being read from a safe location away from the engine.

6.4.3.14 Where alternative methods are provided for the prevention of build-up a potentially explosive condition within the crankcase (independent of the reason, e.g. oil mist, gas, hot spots, etc.), details are to be submitted for consideration of ACS. The following information is to be included in the details to be submitted for approval:

- engine particulars - type, power, speed, stroke, bore and crankcase volume
- details of arrangements preventing the build-up of potentially explosive conditions within the crankcase, e.g. bearing temperature monitoring, oil splash temperature, crankcase pressure monitoring, recirculation arrangements, crankcase atmosphere monitoring
- evidence that the arrangements are effective in preventing the build-up of potentially explosive conditions together with details of in service experience
- operating instructions and maintenance and test instructions

6.4.4 Active safety measures

Where it is proposed to use alternative active technologies to minimize the risk for a potential crankcase explosion, details of the arrangement and the function description are to be submitted to ACS for approval.

6.5 Safety devices in the starting air system

The following equipment is to be fitted to safeguard the starting air system against explosions due to failure of starting valves:

6.5.1 An isolation non-return valve is to be fitted to the starting air line serving each engine.

6.5.2 Engines with cylinder bores of > 230 mm are to be equipped with flame arrestors as follows:

a) on directly reversible engines immediately in front of the start-up valve of each cylinder

b) on non-reversible engines, immediately in front of the intake of the main starting air line to each engine

6.5.3 Equivalent safety devices may be approved by ACS.

6.6 Safety devices in the lubricating oil system

Each engine with a rated power of 220 kW or over is to be fitted with devices which automatically shut down the engine in the event of failure of the lubricating oil supply. This is not valid for engines serving solely for the drive of emergency generator sets and emergency fire pumps. For these engines an alarm has to be provided.

6.7 Safety devices in scavenging air ducts

For two-stroke engines scavenging air ducts are to be protected against overpressure by safety valves.

7 Auxiliary Systems

7.1 General

For piping systems and accessory filter arrangements Section 11 is to be applied, additionally.

7.2 Fuel oil system

7.2.1 General

7.2.1.1 Only pipe connections with metal sealing surfaces or equivalent pipe connections of approved design may be used for fuel injection lines.

7.2.1.2 Feed and return lines are to be designed in such a way that no unacceptable pressure surges occur in the fuel supply system. Where necessary, the engines are to be fitted with surge dampers approved by ACS.

7.2.1.3 All components of the fuel system are to be designed to withstand the maximum peak pressures which will be expected in the system.

7.2.1.4 If fuel oil reservoirs or dampers with a limited life cycle are fitted in the fuel oil system the life cycle together with overhaul instructions is to be specified by the engine manufacturer in the corresponding manuals.

7.2.1.5 Oil fuel lines are not to be located immediately above or near units of high temperature, steam pipelines, exhaust manifolds, silencers or other equipment required to be insulated by 7.7.1. As far as practicable, oil fuel lines are to be arranged far apart from hot surfaces, electrical installations or other potential sources of ignition and are to be screened or otherwise suitably protected to avoid oil spray or oil leakage onto the sources of ignition. The number of joints in such piping systems is to be kept to a minimum.

7.2.2 Shielding

7.2.2.1 Regardless of the intended use and location of internal combustion engines, all external fuel injection lines (high pressure lines between injection pumps and injection valves) are to be shielded by jacket pipes in such a way that any leaking fuel is

- safely collected
- drained away unpressurized and
- effectively monitored and alarmed.

7.2.2.2 If pressure variations of > 20 bar occur in fuel feed and return lines, these lines are also to be shielded.

7.2.2.3 The high pressure fuel pipe and the outer jacket pipe have to be of permanent assembly.

7.2.2.4 Where, pipe sheaths in the form of hoses are provided as shielding, the hoses shall be demonstrably suitable for this purpose and approved by ACS.

7.2.3 Fuel leak drainage

Appropriate design measures are to be introduced to ensure generally that leaking fuel is drained efficiently and cannot enter into the engine lube oil system.

7.2.4 Heating, thermal insulation, re-circulation

Fuel lines, including fuel injection lines, to engines which are operated with preheated fuel are to be insulated against heat losses and, as far as necessary, provided with heating.

Means of fuel re-circulation are also to be provided.

7.2.5 Fuel oil emulsions

For engines operated on emulsions of fuel oil and other liquids it has to be ensured that engine operation can be resumed after failures to the fuel oil treatment system.

7.3 Filter arrangements for fuel oil and lubricating oil systems

7.3.1 Fuel and lubricating oil filters which are to be mounted directly on the engine are not to be located above rotating parts or in the immediate proximity of hot components.

7.3.2 Where the arrangement stated in 7.3.1 is not feasible, the rotating parts and the hot components are to be sufficiently shielded.

7.3.3 Filters have to be so arranged that fluid residues can be collected by adequate means. The same applies to lubricating oil filters if oil can escape when the filter is opened.

7.3.4 Change-over filters with two or more chambers are to be equipped with means enabling a safe pressure release before opening and a proper venting before re-starting of any chamber. Normally, shut-off devices are to be used. It shall be clearly visible, which chamber is in and which is out of operation.

7.3.5 Oil filters fitted parallel for the purpose of enabling cleaning without disturbing oil supply to engines (e.g. duplex filters) are to be provided with arrangements that will minimize the possibility of a filter under pressure being opened by mistake. Filters/ filter chambers shall be provided with suitable means for:

- venting when put into operation
- depressurizing before being opened.

Valves or cocks with drain pipes led to a safe location shall be used for this purpose.

7.3.6 In addition the requirements of Section 8 have to be considered also for filters.

7.4 Lubricating oil system

7.4.1 General requirements relating to lubricating oil systems and to the cleaning, cooling, etc. of the lubricating oil are contained in Section 11. For piping arrangement 7.2.1.5 is to be applied.

7.4.1.1 Engines which sumps serve as oil reservoirs shall be so equipped that the oil level can be established and, if necessary, topped up during operation. Means shall be provided for completely draining the oil sump.

7.4.1.2 The combination of the oil drainage lines from the crankcases of two or more engines is not allowed.

7.4.1.3 The outlet ends of the drain lines from the engine sump shall be below the oil level in the drain tank.

7.4.2 Engine lubricating oil

7.4.2.1 Main lubricating oil pumps driven by the engine are to be designed to maintain the supply of lubricating oil over the entire operating range.

7.4.2.2 Main engines which drive main lubricating oil pumps are to be equipped with independently driven stand-by pumps.

7.4.2.3 In multi-engine installations having separate lubricating oil systems approval may be given for the carriage on board of reserve pumps ready for mounting provided that the arrangement of the main lubricating oil pumps enables the change to be made with the means available on board.

7.4.2.4 Lubricating oil systems for cylinder lubrication which are necessary for the operation of the engine and which are equipped with electronic dosing units have to be approved by ACS.

7.5 Cooling system

7.5.1 For the equipment of engines with cooling water pumps and for the design of cooling water systems, see Section 11.

7.5.1.1 Main cooling water pumps driven by the engine are to be designed to maintain the supply of cooling water over the entire operating range.

7.5.1.2 Main engines which drive main cooling water pumps are to be equipped with independently driven stand-by pumps or with means for connecting the cooling water system to independently driven stand-by pumps.

7.5.1.3 In multi-engine installations having separate fresh cooling water systems approval may be given for the carriage on board of reserve pumps ready for mounting provided that the arrangement of the main fresh cooling water pumps enables the change to be made with the means available on board. Shutoff valves shall be provided enabling the main pumps to be isolated from the fresh cooling water system.

7.5.2 If cooling air is drawn from the engine room, the design of the cooling system is to be based on a room temperature of at least 45 °C.

The exhaust air of air-cooled engines may not cause any unacceptable heating of the spaces in which the plant is installed. The exhaust air is normally to be led to the open air through special ducts.

7.5.3 Where engines are installed in spaces in which oil-firing equipment is operated, ACS requirements are to be complied with.

7.6 Charge air system

7.6.1 Exhaust gas turbochargers

7.6.1.1 The construction and testing of exhaust gas turbochargers are covered by Section 4.

7.6.1.2 Exhaust gas turbochargers may exhibit no critical speed ranges over the entire operating range of the engine.

7.6.1.3 The lubricating oil supply shall also be ensured during start-up and run-down of the exhaust gas turbochargers.

7.6.1.4 Even at low engine speeds, main engines shall be supplied with charge air in a manner to ensure reliable operating.

Where necessary, two-stroke engines are to be equipped with directly or independently driven scavenging air blowers.

7.6.1.5 If, in the lower speed range or when used for maneuvering, an engine can be operated only with a charge air blower driven independently of the engine, a stand-by charge air blower is to be installed or an equivalent device of approved design.

7.6.1.6 With main engines emergency operation must be possible in the event of a turbocharger failure.

7.6.2 Charge air cooling

7.6.2.1 Means are to be provided for regulating the temperature of the charge air within the temperature range specified by the engine manufacturer.

7.6.2.2 The charge air lines of engines with charge air coolers are to be provided with sufficient means of drainage.

7.6.3 Fire extinguishing equipment

The charge air receivers of crosshead engines which have open connection to the cylinders are to be connected to an approved fire extinguishing system which is independent of the engine room fire extinguishing system.

7.7 Exhaust gas lines

7.7.1 Exhaust gas lines are to be insulated and/or cooled in such a way that the surface temperature cannot exceed 220 °C at any point. Insulating materials shall be non-combustible.

7.7.2 General rules relating to exhaust gas lines are contained in Section 11.

8 Starting Equipment

8.1 General

8.1.1 Engine starting equipment shall enable engines to be started up from "dead ship" condition according to Section 1, 4.6.1 using only the means available on board.

8.1.2 Means are to be provided to ensure that auxiliary and emergency diesel engines can be started after black-out and "dead-ship" condition. This is to be considered especially for electronically controlled engines (e.g. common rail).

8.1.3 The ACS Guidelines for the Construction of Polar Class Ships are to be observed for ships with Ice Class Notations.

8.2 Starting with compressed air

8.2.1 Starting air systems for main engines are to be equipped with at least two starting air compressors. At least one of the air compressors shall be driven independently of the main engine and shall supply at least 50 % of the total capacity required.

8.2.2 The total capacity of the starting air compressors is to be such that the starting air receivers designed in accordance with 8.2.4 or 8.2.5, as applicable, can be charged from atmospheric pressure to their final pressure within one hour.

Normally, compressors of equal capacity are to be installed.

This does not apply to an emergency air compressor which may be provided to meet the requirement stated in 8.1.

8.2.3 If the main engine is started with compressed air, the available starting air is to be divided between at least two starting air receivers of approximately equal size which can be used independently of each other.

8.2.4 The total capacity of air receivers is to be sufficient to provide, without their being replenished, not less than 12 consecutive starts alternating between Ahead and Astern of each main engine of the reversible type, and not less than six starts of each main nonreversible type engine connected to a controllable pitch propeller or other device enabling the start without opposite torque.

8.2.5 With multi-engine installations the number of start-up operations per engine may, with ACS's agreement, be reduced according to the concept of the propulsion plant.

8.2.6 If starting air systems for auxiliaries or for supplying pneumatically operated regulating and maneuvering equipment or typhon units are to be fed from the main starting air receivers, due attention is to be paid to the air consumption of this equipment when calculating the capacity of the main starting air receivers.

8.2.7 Other consumers with a high air consumption apart from those mentioned in 8.2.6 may not be connected to the main starting air system. Separate air supplies are to be provided for these units. Deviations to this require the agreement of ACS.

8.2.8 If auxiliary engines are started by compressed air sufficient air capacity for three consecutive starts of each auxiliary engine is to be provided.

8.2.9 If starting air systems of different engines are fed by one receiver it is to be ensured that the receiver air pressure cannot fall below the highest of the different systems minimum starting air pressures.

8.2.10 Approximate calculation of the starting air supply

For the approximate calculation of the starting air supply the following formulae may be used.

8.2.10.1 Starting air for installations with reversible engines

Assuming an initial pressure of 30 bar and a final pressure of 9 bar in the starting air receivers, the preliminary calculation of the starting air supply for a reversible main engine may be performed as follows:

$$J = a \cdot \sqrt[3]{H/D}\,(z + b\, p_{e,e}\, n_A + 0.9)\, V_h\, c$$

J = total capacity of the starting air receivers [dm^3]

D = cylinder bore [mm]

H = stroke [mm]

V_h = swept volume of one cylinder (in the case of double-acting engines, the swept volume of the upper portion of the cylinder) [dm^3]

$p_{e,zul}$ = maximum permissible working pressure of the starting air receiver [bar]

z = number of cylinders [–]

$p_{e,e}$ = mean effective working pressure in cylinder at rated power [bar]

The following values of "a" are to be used:

- for two-stroke engines: a = 0.4714
- for four-stroke engines: a = 0.4190

The following values of "b" are to be used:

- for two-stroke engines: b = 0.059
- for four-stroke engines: b = 0.056

The following values of "c" are to be used:

c = 1, where $p_{e,zul}$ = 30 bar

$c = 0.0584/(1 - e^{(0.11 - 0.05 \ln p_{e,zul})})$ where $p_{e,zul}$ > 30 bar, if no pressure-reducing valve is fitted.

e = Euler's number (2,718....) [–]

Where $p_{e,zul}$ > 30 bar, if a pressure-reducing valve is fitted, which reduces the pressure $p_{e,zul}$ to the starting pressure P_A, the value of "c" shown in Figure 8.1 is to be used.

The following values of nA are to be applied:

$n_A = 0.06\, n_o + 14$ where $n_o \leq 1000$

$n_A = 0.25\, n_o - 176$ where $n_o > 1000$

n_o = rated speed [min^{-1}]

8.2.10.2 Starting air for installations with nonreversible engines

For each non-reversible main engine driving a controllable pitch propeller or where starting without torque resistance is possible the calculated starting air supply may be reduced to 0.5 J though not less than that needed for six start-up operations.

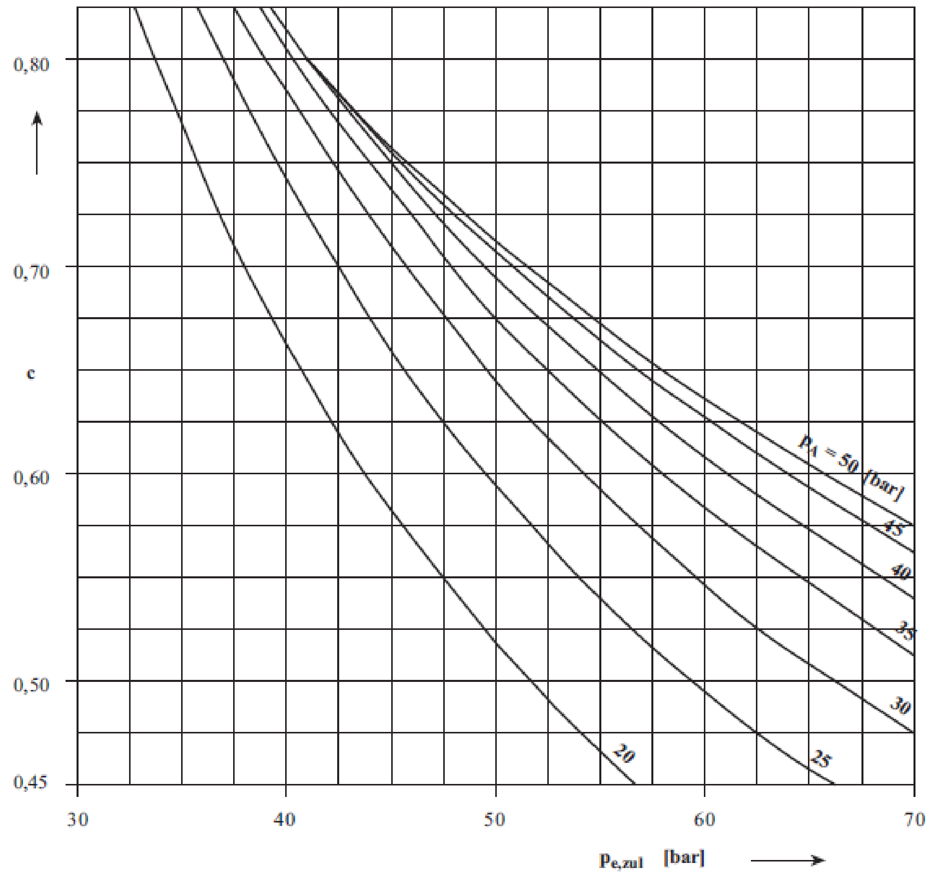


Figure 8.1: The value of "c" where a pressure-reducing valve is fitted

8.3 Electrical starting equipment

8.3.1 Where main engines are started electrically, two mutually independent starter batteries are to be installed. The batteries are to be so arranged that they cannot be connected in parallel with each other. Each battery shall enable the main engine to be started from cold.

The total capacity of the starter batteries must be sufficient for the execution within 30 minutes, without recharging the batteries, of the same number of startup operations as is prescribed in 8.2.4 or 8.2.5 for starting with compressed air.

8.3.2 If two or more auxiliary engines are started electrically, at least two mutually independent batteries are to be provided. Where starter batteries for the main engine are fitted, the use of these batteries is acceptable.

The capacity of the batteries shall be sufficient for at least three start-up operations per engine.

If only one of the auxiliary engines is started electrically, one battery is sufficient.

8.3.3 The starter batteries shall only be used for starting (and preheating where applicable) and for monitoring equipment belonging to the engine.

8.3.4 Steps are to be taken to ensure that the batteries are kept charged and the charge level is monitored.

8.4 Start-up of emergency generating sets

8.4.1 Emergency generating sets are to be so designed that they can be started up readily even at a temperature of 0°C.

If the set can be started only at higher temperatures, or where there is a possibility that lower ambient temperatures may occur, heating equipment is to be fitted to ensure ready reliable starting.

The operational readiness of the set shall be guaranteed under all weather and seaway conditions. Fire flaps required in air inlet and outlet openings shall only be closed in case of fire and are to be kept open at all other times. Warning signs to this effect are to be installed. In the case of automatic fire flap actuation dependent on the operation of the set warning signs are not required. Air inlet and outlet openings shall not be fitted with weatherproof covers.

8.4.2 Each emergency generating set required to be capable of automatic starting is to be equipped with an automatic starting system approved by ACS, the capacity of which is sufficient for at least three consecutive starts.

Additionally a second source of energy is to be provided capable of three further starting operations within 30 minutes. This requirement is not applicable if the set can be started manually.

8.4.3 In order to guarantee the availability of the starting equipment, steps are to be taken to ensure that

a) electrical and hydraulic starting systems are supplied with energy from the emergency switchboard

b) compressed air starting systems are supplied via a non-return valve from the main and auxiliary compressed air receivers or by an emergency air compressor, the energy for which is provided via the emergency switchboard and

c) the starting, charging and energy storage equipment is located in the emergency generator room.

8.4.4 Where automatic starting is not specified, reliable manual starting systems may be used, e.g. by means of hand cranks, spring-loaded starters, hand-operated hydraulic starters or starters using ignition cartridges.

8.4.5 Where direct manual starting is not possible, starting systems in accordance with 8.4.2 and 8.4.3 are to be provided, in which case the starting operation may be initiated manually.

8.4.6 The starters of emergency generator sets shall be used only for the purpose of starting the emergency generator sets.

8.5 Start-up of emergency fire-extinguisher sets

8.5.1 Diesel engines driving emergency fire pumps are to be so designed that they can still be reliably started by hand at a temperature of 0 °C.

If the engine can be started only at higher temperatures, or where there is a possibility that lower temperatures may occur, heating equipment is to be fitted to ensure reliable starting.

8.5.2 If manual start-up using a hand crank is not possible, the emergency fire-extinguisher set is to be fitted with a starting device approved by ACS which enables at least 6 starts to be performed within 30 minutes, two of these being carried out within the first 10 minutes.

9 Control Equipment

9.1 General

For unmanned machinery installations, ACS Rules for Automation, Ch. 3 is to be observed in addition to the following requirements.

9.2 Main engines

9.2.1 Local control station

To provide emergency operation of the propulsion plant a local control station is to be installed from which the plant can be operated and monitored.

9.2.1.1 Indicators according to Table 9.1 are to be clearly sited on the local main engine control station.

9.2.1.2 Temperature indicators are to be provided on the local control station or directly on the engine.

9.2.1.3 In the case of gear and controllable pitch propeller systems, the local control indicators and control equipment required for emergency operation are to be installed at the main engines local control station.

9.2.1.4 Critical speed ranges are to be marked in red on the tachometers.

Table 9.1: Alarms and indicators

Description	Propulsion engines	Auxiliary engines	Emergency engines
speed / direction of rotation	I		
engine overspeed [5]	A,S	A,S	A,S
lubricating oil pressure at engine inlet	I, L[9], S	I, L[9], S	I, L[9], S
lubricating oil temperature at engine inlet	I, H	I[5], H[5]	I[5], H[5]
fuel oil pressure at engine inlet	I	I	
fuel oil temperature at engine inlet [1]	I	I	
fuel oil leakage from high pressure pipes	A	A	A
cylinder cooling water pressure at engine inlet	I, L	I[4], L[4]	I[4], L[4]
cylinder cooling water temperature at engine outlet	I, H	I, H	I, H
piston coolant pressure at inlet	I, L		
piston coolant temperature at outlet	I, H		
charge air pressure at cylinder inlet	I		
charge air temperature at charge air cooler inlet	I		
charge air temperature at charge air cooler outlet	I, H		
starting air pressure	I, L		
control air pressure	I, L		
exhaust gas temperature [2]	I, H[3]		
oil mist concentration in crankcase or alternative monitoring system [6, 7, 8]	I,H	I,H	I,H

1) for engines running on heavy fuel oil only

2) where ever the dimensions permit, at each cylinder outlet and at the turbocharger inlet and outlet

3) at turbocharger outlet only

4) cooling water pressure or flow

5) only for an engine output ≥ 220 kW

6) for engines having an output ≥ 2250 kW or a cylinder bore > 300 mm

7) alternative methods of monitoring may be approved by ACS

8) an engine shutdown may be provided where necessary

9) only for an engine output > 37 kW

I: Indicator A: Alarm H: Alarm for upper limit L: Alarm for lower limit

S: Shutdown

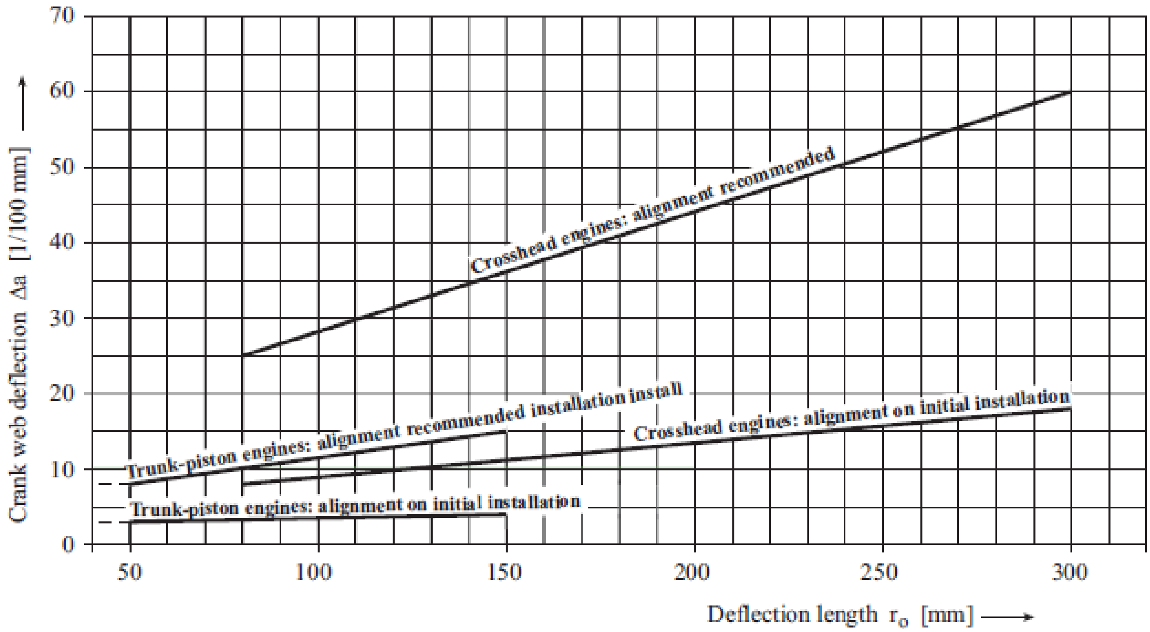


Figure 9.1: Reference values for crank web deflection

9.2.2 Machinery control room/control centre

For remotely operated or controlled machinery installations the indicators listed in Table 9.1 are to be installed, see ACS Rules for Automation Ch. 3.

9.2.3 Bridge/navigation centre

9.2.3.1 The essential operating parameters for the propulsion system are to be provided in the control station area.

9.2.3.2 The following stand-alone control equipment is to be installed showing:

- speed/direction of rotation of main engine

- speed/direction of rotation of shafting
- propeller pitch (controllable pitch propeller)
- starting air pressure
- control air pressure

9.2.3.3 In the case of engine installations up to a total output of 600 kW, simplifications can be agreed with ACS.

9.3 Auxiliary engines

For auxiliary engines and emergency application engines the controls according to Table 9.1 are to be provided as a minimum.

10 Alarms

10.1 General

10.1.1 The following requirements apply to machinery installations which have been designed for conventional operation without any degree of automation.

10.1.2 Within the context of these requirements, the word alarm is to be understood as the visual and audible warning of abnormal operating parameters.

10.1.3 The ACS Rules for Automation Ch. 3 are to be observed for the layout of alarm and safety system.

10.2 Scope of alarms

Alarms have to be provided for main, auxiliary and emergency engines according to Table 9.1.

11 Engine Alignment/Seating

11.1 Engines are to be mounted and secured to their shipboard foundations in conformity with requirements for the Seating of Propulsion Plants and Auxiliary Machinery.

11.2 The crankshaft alignment is to be checked every time an engine has been aligned on its foundation by measurement of the crank web deflection and/ or other suitable means.

For the purpose of subsequent alignments, note is to be taken of:

– the draught/load condition of the vessel

– the condition of the engine - cold/preheated/hot

11.3 Where the engine manufacturer has not specified values for the permissible crank web deflection, assessment is to be based on ACS's reference values.

11.4 Reference values for crank web deflection

11.4.1 Irrespective of the crank web deflection figures quoted by the manufacturers of the various engine types, reference values for assessing the crank web deflection in relation to the deflection length ro can be taken from Figure 9.1. Provided that these values are not exceeded, it may be assumed that neither the crankshaft nor the crankshaft bearings are subjected to any unacceptable additional stresses.

11.4.2 Notes on the measurement of crank web deflections

Crank web deflections are to be measured at distance

$R + d_w/2$

from the crankpin centre line (see Figure 11.1)

Crank web deflection Δa is only meaningful as measured between opposite crank positions (see Figure 11.1), i.e. between 0 - 3 for evaluating vertical alignment and bearing location, and between 2 - 4 for evaluating lateral bearing displacement when aligning the crankshaft and assessing the bearing wear. For measuring point 0, which is obstructed by the connecting rod, the mean value of the measurements made at 1' and 1" is to be applied.

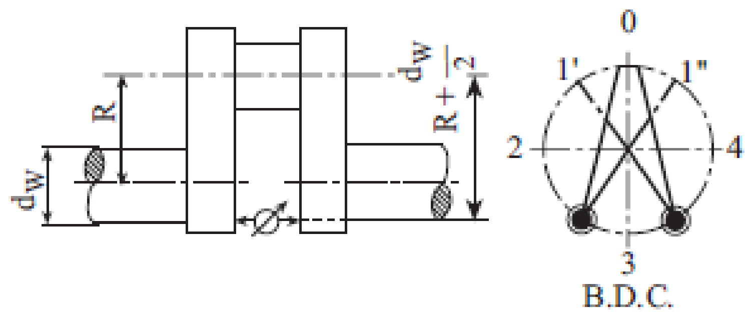


Figure 11.1: Measurements of crank web deflections

11.4.3 Determining the crank web deflection length r_o

Explanatory notes on:

- solid-forged and drop-forged crankshafts in Figure 11.2, subfigures A, B and C;
- semi-built crankshafts, subfigure D.

Symbols:

R = crank radius [mm]

H = stroke (2 R) [mm]

d_k = crank pin diameter [mm]

d_w = journal diameter [mm]

d_N = shrink annulus diameter [mm]

W = axial web thickness [mm]

B = web width at distance R/2 [mm]

T_i = depth of web undercut (on crank pin side) [mm]

T_a = depth of web undercut (on journal side) [mm]

s = pin/journal overlap [mm] = $(d_k + dw)/2-R$

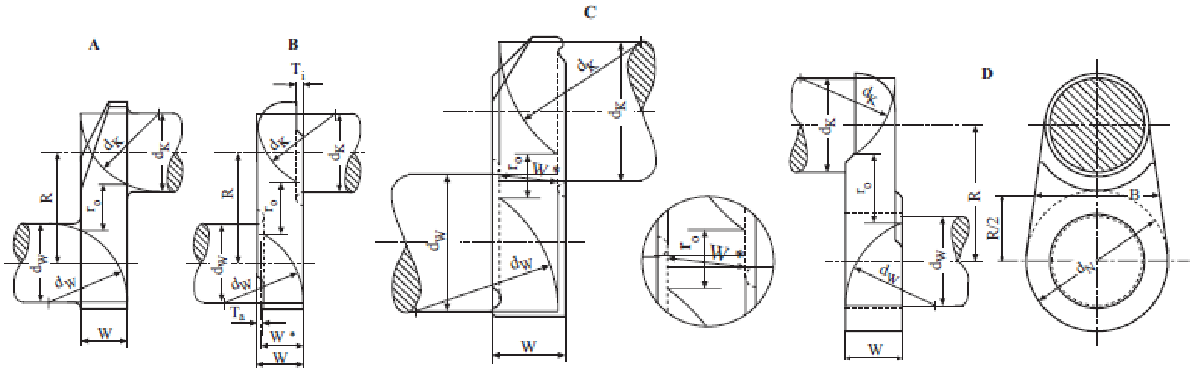


Figure 11.2: Types of forged (A, B and C) and semibuilt (D) crankshafts

Where there is a negative pin/journal overlap (s < 0), the deflection length ro in accordance with subfigure A is determined by applying the formula:

$$r_o = 0.5(H + d_k + d_w) - W\left(\sqrt{\frac{2d_k}{W} - 1} + \sqrt{\frac{2d_W}{W} + 1}\right) \qquad (1)$$

In case of web undercut, W in formula (1) is to be replaced by:

$$W^* = W - \frac{(T_i + T_a)}{2} \qquad (2)$$

In the case of semi-built crankshafts in accordance with subfigure D, the value d_w in the radicand of formula (1) is to be replaced by:

$$dw^* = \frac{1}{3}(d_N - d_W) + d_W \qquad (3)$$

In case of web undercut, W* is also to be substituted for W in accordance with formula (2).

Where there is a positive pin/journal overlap (s ≥0) according to subfigure C, the value W in formula (1) is to be replaced by:

$$W^* = \sqrt{(W - T_i - T_a)^2 + [0.5(d_k + d_W - H)]^2} \qquad (4)$$

For the conventional designs, where

B/d_w = 1.37 to 1.51 in the case of solid-forged crankshafts, and

B/d_w = 1.51 to 1.63 in the case of semi-built crankshafts,

the influence of B in the normal calculation of ro is already taken into account in the values of Δa in Figure 9.1.

Where the values of B/d_w depart from the above (e.g. in the case of discs, oval webs, etc.), the altered stiffening effect of B is to be allowed for by a fictitious web thickness W**, which is to be calculated by applying the following equations and is to be substituted for W in formula (1):

$$W^{**} = W^{*}\sqrt[3]{\frac{B}{d_W} - 0.44} \qquad \text{for solid forged crankshafts}$$

$$W^{**} = W^{*}\sqrt[3]{\frac{B}{d_W} - 0.57} \qquad \text{for semibuilt crankshafts}$$

12 Approximate Calculation of the Starting Air Supply

These calculations are integrated in 8.2.10.

13 Air Compressors

13.1 General

13.1.1 Scope

These requirements apply to reciprocating compressors of the normal marine types. Where it is intended to install compressors to which the following requirements and calculation formulae cannot be applied, ACS requires proof of their suitability for shipboard use.

13.1.2 Documents for approval

Drawings showing longitudinal and transverse cross sections, the crankshaft and the connecting rod are to be submitted to ACS. In specific cases and following prior agreement with ACS they can also be submitted in paper form in triplicate for each compressor type.

13.2 Materials

13.2.1 Approved materials

In general, the crankshafts and connecting rods of reciprocating compressors shall be made of steel, cast steel or nodular cast iron. The use of special cast iron alloys is to be agreed with ACS.

13.2.2 Material testing

Material tests are to be performed on crankshafts with a calculated crank pin diameter of > 50 mm. For crank pin diameters of ≤ 50 mm a Manufacturer Inspection Certificate is sufficient.

13.3 Crankshaft dimensions

13.3.1 The diameters of journals and crank pins are to be determined as follows:

$$d_k = 0.126\ \sqrt[3]{D^2\ p_c\ C_1 C_W\ (2H + f\ L)}$$

d_k = minimum pin/journal diameter [mm]

D = cylinder bore for single-stage compressors [mm]

= D_{Hd} = cylinder bore of the second stage in two-stage compressors with separate pistons

= 1.4 D_{Hd} for two stage compressors with a stepped piston as in Figure 13.1

$= \sqrt{D_{Nd}^2 - D_{Hd}^2}$ for two-stage compressors with a differential piston as in Figure 13.2

p_c = design pressure PR, applicable up to 40 [bar]

H = piston stroke [mm]

L = distance between main bearing centres where one crank is located between two bearings [mm].

L is to be substituted by L_1 = 0.85 L where two cranks at different angles are located between two main bearings, or by L_2 = 0.95 L where 2 or 3 connecting rods are mounted on one crank.

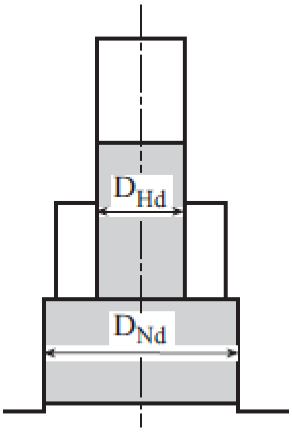


Figure 13.1

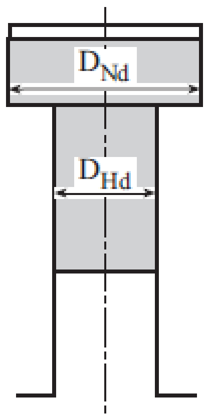


Figure 13.2

f = 1.0, where the cylinders are in line

=1. 2, where theccylinders are at 90

=1.5, where the cylinders are at 60 V- or W type

=1.8, where the cylinders are at 45

C_1 = coefficient according to Table 13.1 [–]

z = number of cylinders

C_w = material factor according to Table 13.2 or 13.3 [–]

R_m = minimum tensile strength [N/mm^2]

13.3.2 Where increased strength is achieved by a favourable configuration of the crankshaft, smaller values of dk may be approved.

13.4 Construction and equipment

13.4.1 General

13.4.1.1 Cooler dimensions are to be based on a seawater temperature of at least 32 °C in case of water cooling, and on an air temperature of at least 45 °C in case of air cooling, unless higher temperatures are indicated by the temperature conditions according to the ship's trade or by the location of the compressors or cooling air intakes.

Where fresh water cooling is used, the cooling water inlet temperature shall not exceed 40 °C.

13.4.1.2 Unless they are provided with open discharges, the cooling water spaces of compressors and coolers shall be fitted with safety valves or rupture discs of sufficient cross-sectional area.

13.4.1.3 High-pressure stage air coolers shall not be located in the compressor cooling water space.

Table 13.1: Values of C_1

z	1	2	4	6	≥ 8
C_1	1.0	1.1	1.2	1.3	1.4

Table 13.2: Values of C_w for steel shafts

R_m	C_w
400	1.03
440	0.94
480	0.91
520	0.85
560	0.79
600	0.77
640	0.74
≥680	0.70
720[1]	0.66
≥760[1]	0.64

1) Only for drop-forged crankshafts.

Table 13.3: Values of C_w for nodular cast iron shafts

R_m	C_w
370	1.2
400	1.10
500	1.08
600	0.98
700	0.94
≥800	0.90

13.4.2 Safety valves and pressure gauges

13.4.2.1 Every compressor stage shall be equipped with a suitable safety valve which cannot be blocked and which prevents the maximum permissible working pressure from being exceeded by more than 10 % even when the delivery line has been shut off. The setting of the safety valve shall be secured to prevent unauthorized alteration.

13.4.2.2 Each compressor stage shall be fitted with a suitable pressure gauge, the scale of which must indicate the relevant maximum permissible working pressure.

13.4.2.3 Where one compressor stage comprises several cylinders which can be shut off individually, each cylinder shall be equipped with a safety valve and a pressure gauge.

13.4.3 Air compressors with oil-lubricated pressure spaces

13.4.3.1 The compressed air temperature, measured directly at the discharge from the individual stages, may not exceed 160 °C for multi-stage compressors or 200 °C for single-stage compressors. For discharge pressures of up to 10 bar, temperatures may be higher by 20 °C.

13.4.3.2 Compressors with a power consumption of more than 20 kW shall be fitted with thermometers at the individual discharge connections, wherever this is possible. If this is not practicable, they are to be mounted at the inlet end of the pressure line. The thermometers are to be marked with the maximum permissible temperatures.

13.4.3.3 After the final stage, all compressors are to be equipped with a water trap and an after cooler.

13.4.3.4 Water traps, aftercoolers and the compressed air spaces between the stages shall be provided with discharge devices at their lowest points.

13.4.4 Name plate

Every compressor is to carry a name plate with the following information:

– manufacturer

– year of construction

– effective suction rate [m^3/h]

– discharge pressure [bar]

– speed [min^{-1}]

– power consumption [kW]

13.5 Tests

13.5.1 Pressure tests

13.5.1.1 Cylinders and cylinder liners are to be subjected to hydraulic pressure tests at 1,5 times the final pressure of the stage concerned.

13.5.1.2 The compressed air chambers of the intercoolers and after coolers of air compressors are to be subjected to hydraulic pressure tests at 1,5 times the final pressure of the stage concerned.

13.5.2 Final inspections and testing

Compressors are to be subjected to a performance test at the manufacturer's works under supervision of ACS and are to be presented for final inspection.

14 Exhaust Gas Cleaning Systems

14.1 General

Exhaust gas cleaning systems shall comply with the applicable statutory requirements. Requirements stipulated in the MARPOL Convention as well as further IMO Guidelines, as far as applicable, are to be observed.

14.1.1 Application

The following requirements apply to exhaust gas cleaning systems which reduce the amount of nitrogen oxides (NOx), sulphur oxides (SOx) and/or particulate matter from the exhaust gases of internal combustion engines, incinerators or steam boilers.

14.2 Approval

Where an exhaust gas cleaning system is installed details of the arrangement and a description of the functionality are to be submitted to ACS for approval.

In specific cases and following prior agreement with ACS they can also be submitted in paper form in triplicate.

14.2.1 Documents for approval

The following documents are to be submitted for approval:

- Drawings showing the main dimensions of the system, including documentation concerning installation requirements and operational features,
- Safety concept addressing design and operational issues,
- Operating manual, including instructions for maintenance, verification of parameters indicating the need for cleaning or replacement, and instructions for emergency operation, if applicable.

14.2.2 Approval certificate

After successful appraisal of the required documents and successful conclusion of the shipboard test in presence of a Surveyor, ACS will issue an Approval Certificate.

14.3 Layout

14.3.1 System layout and installation

Exhaust gas cleaning systems shall be separate for each combustion engine or combustion plant, as a matter of principle. However, other arrangements may be considered for approval on a case-by-case basis following further detailed examination of e.g. possible adverse effect on other engines or exhaust gas back flow. General requirements for the use of combustible materials and structural fire protection are to be observed. Thermal expansion of the system and its mechanical connections to both the ship’s structure and the exhaust pipes are to be considered. The after treatment system is to be equipped with at least one inspection port.

Exemptions may be granted for applications on small bore high-speed mass produced engines.

Exhaust gas cleaning systems are to be accessible for inspection and maintenance. Exchange or removal of internal components shall be possible, where applicable.

14.3.2 Safety concept

The safety concept is a document describing hazards associated with the design and operation of the exhaust gas cleaning system along with suitable measures to control the identified hazards. The safety concept shall be a self contained document covering the following:

- System description with schematic diagrams of the plant layout
- Hazard analysis for design and operational aspects of the exhaust gas cleaning system. The analysis shall address inter alia:
- Fresh water and sea water systems (e.g. high/low temperatures, system clogging, flooding)
- Process chemicals (e.g. storage, ventilation, high/low temperatures)
- Exhaust gas piping system (e.g. pressure fluctuations)
- Fire hazards
- Material selection
- Ship motions
- Control measures for all identified hazards

14.3.3 Bypass

Where an exhaust gas cleaning system is installed with a single main propulsion engine a bypass, controlled by flap valves or other suitable cut-off devices, is required in order to allow unrestricted engine operation in case of system failure. The bypass shall be designed for the maximum exhaust gas mass flow at full engine load.

If an exhaust gas cleaning system is installed on an engine of a multi engine plant a bypass system may be dispensed with.

14.3.4 Additional pressure loss

The total pressure loss in the exhaust gas system, including the additional pressure loss from the exhaust gas cleaning system, must not exceed the load dependent maximum allowable exhaust gas back pressures as specified by the engine manufacturer at any load condition.

14.3.5 Maximum gas pressure

The maximum pressure in the system of the exhaust pipes as specified by the manufacturer shall not be exceeded. Care is to be taken in particular where the exhaust gas cleaning system is located upstream of the turbocharger of a combustion engine (e.g. Selective Catalytic Reduction systems in conjunction with large bore 2-stroke Diesel engines).

14.3.6 Oscillation characteristics of the exhaust gas column

The installation and operation of the exhaust gas cleaning system shall not have an adverse effect on the oscillation characteristics of a combustion engine's exhaust gas column in order to avoid unsafe engine operation.

14.3.7 Deposition of soot

Exhaust gas cleaning systems shall be designed and operated so that the deposition of soot is minimized.

Any deposition of soot that may lead to additional fire hazards is not acceptable.

14.3.8 Vibrations in piping system

The design and installation of the exhaust gas cleaning system including the exhaust gas piping system shall account for vibrations induced by the ship's machinery, the pulsation of the exhaust gas or vibrations transmitted through the ship's structure in order to prevent mechanical damage to the piping system.

Consideration should be given to the installation of damping systems and/or compensators.

14.3.9 Monitoring of the operating parameters

The main operating parameters of the exhaust gas cleaning system have to be monitored and should serve as indicators for possible abnormal operating conditions. As a minimum, the following operating parameters shall be monitored:

- Gas temperature upstream of the exhaust gas cleaning system
- Gas temperature downstream of the exhaust gas cleaning system
- Pressure drop across the exhaust gas cleaning system
- Engine exhaust gas back pressure
- Position of flap valves / cut-off devices

14.4 Materials

All materials of the exhaust gas cleaning system, connecting pipes and chemically reactive agent dosing units shall be non-combustible. Where plastic piping is intended to be used in wet scrubber systems the requirements in Section 11. The requirements relating to exhaust gas lines as contained in Section 11are to be observed, as applicable.

14.5 Handling of noxious process substances

14.5.1 Urea solution for SCR

Tanks may be of the integrated or independent type.

They may be part of the ship's side shell.

Structural materials used for tank construction, together with associated piping, pumps, valves, vents and their jointing materials shall be of stainless steel or carbon steel with an adequate corrosion allowance.

The recommended construction material is stainless steel. No copper or copper alloy parts may be used.

The tanks shall be provided with temperature and level indication.

The outlet of the tank venting system shall lead to the open deck and the terminal shall be arranged in an area not usually accessible.

14.5.2 Ammonia solution for SCR

Ammonia solution (Ammonia Aqueous) shall be stored in independent tanks, not less than 760 mm from the shell plating.

Tanks shall be equipped with a high level alarm (95%) and a gauging device in accordance with the ACS Rules for Chemical Tankers.

Tanks and all related processing equipment shall be placed in designated compartments, gas-tight isolated from all adjacent spaces.

All tanks, pipes, pumps, valves, vents and their jointing materials shall be made of stainless steel. Other materials may be accepted on a case-by-case basis.

Access to such compartments shall be fitted with two doors forming an air-lock, both gas-tight, self-closing and without holding-back arrangements. The compartment shall be power-ventilated. In the air-lock an overpressure relative to the compartment shall be maintained. The air-lock ventilation can be dispensed with if the door leads to the open deck.

The ventilation system for the compartment shall be of the extraction type and capable of maintaining 8 changes of the compartment volume per hour.

The outlet shall be positioned at least 6 m above the weather deck and horizontally not less than 10 m away from all air intakes, openings to accommodation, service and machinery spaces or sources of ignition.

A drip tray shall be provided, covering the complete area underneath the tanks, valves and other components from which leakages can occur. The drip tray shall be connected to a designated drain tank. The contents of drain tanks shall be discharged overboard under water. Discharge criteria in MARPOL Annex II and in national regulations, as applicable, are to be observed.

The tanks for ammonia solution and the drain tanks shall be fitted with individual means of controlled venting.

The position of the vent heads shall be at least 6 m above the weather deck and horizontally not less than 10 m away from all air intakes, openings to accommodation, service and machinery spaces or sources of ignition.

Ammonia solution pipes outside the protected compartment shall be arranged within pipe ducts. These pipe ducts shall be extraction ventilated mechanically with 8 changes per hour. The exhaust shall be positioned at least 6 m above the weather deck and horizontally not less than 10 m away from all air intakes, openings to accommodation, service and machinery spaces or sources of ignition.

Monitoring for toxic gases shall be maintained continuously within the tank compartment.

The tank compartment shall be fire protected by a water spray system.

14.5.3 Sodium hydroxide solution (NaOH) for wet scrubbers.

Tanks may be of the integrated or independent type.

They may be part of the ship’s side shell.

Structural materials used for tank construction, together with associated piping, pumps, valves, vents and their jointing materials shall be of stainless steel or carbon steel with an adequate corrosion allowance.

For temperatures above 50 °C the recommended construction material is stainless steel. No aluminium, zinc or galvanized steel parts may be used.

The tanks shall be provided with a heating system.

The tanks shall be provided with temperature and high level alarm (95 %) and a gauging device.

The outlet of the tank venting system shall lead to the open deck and the terminal shall be arranged in an area not usually accessible.

14.5.4 Reducing agent

For Selective Catalytic Reduction (SCR) type exhaust gas cleaning systems, tanks and pipes for the reducing agent (such as ammonia, dissolved ammonia and urea) are to be made of approved materials for the specific type of agent. Minimum and maximum storage temperatures are to be specified.

14.5.5 Ammonia slip

Where Selective Catalytic Reduction (SCR) type exhaust gas cleaning systems are applied excessive slip of ammonia has to be prevented.

14.5. 6 Washwater criteria

Where the exhaust gases are washed with water, discharged wash water has to comply with criteria as specified in IMO Resolution MEPC.184 (59).

14.6 Shipboard testing

The exhaust gas cleaning and bypass system is subject to inspection and functional tests in each case in the presence of a Surveyor.

15 Gas-Fuelled Engines

15.1 Scope and application

15.1.1 For internal combustion engines using gas as fuel the following requirements are to be observed.

These requirements are applicable to gas-fuelled engines meeting the following criteria:

- engines using natural gas as fuel engines using gases other than natural gas will be specially considered and additional respectively adapted requirements may apply
- engines burning fuel gas and fuel oil (dual-fuel engines), or single gas fuel engines (operating on gas-only)
- engines with low or high pressure gas supply systems

15.1.2 Special design features will be considered on a case by case basis, taking into account the basic engine design and the engine safety concept.

15.2 Further Rules and Guidelines

15.2.1 The basic gas-fuelled engine requirements defined in the Guidelines for the Use of Gas as Fuel for Ships are generally to be fulfilled independent of the source of gas (boil-off from cargo or gas fuel from storage tanks).

15.2.2 Requirements for internal combustion engines as defined in these ACS Rules from 1. to 14. are to be followed for gas-fuelled engines as far as applicable.

15.2.3 Guidelines for the Use of Gas as Fuel for Ships apply to gas fuel supplied from gas fuel storage tanks.

15.2.4 Rules for Liquefied Gas Carriers apply to gas fuel supplied from liquefied gas carrier cargo boil-off.

Note:

Use of gas as fuel for ships is currently not covered by international conventions (except boil-off from cargo covered by the IGC Code). Therefore, acceptance by the flag administration is necessary for each individual installation.

Resolution MSC.285(86) 'Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships' gives guidance on safety requirements for these installations.

15.3 Definitions

15.3.1 Definitions addressing gas as fuel as given in the Guidelines for the Use of Gas as Fuel for Ships apply.

15.3.2 Gas admission valve: Valve or injector on the engine which controls gas supply to the engine according to the engine's actual gas demand.

15.3.3 Safety concept: The safety concept is a document describing the safety philosophy with regard to gas as fuel. It describes how risks associated with this type of fuel are controlled under normal operating conditions as well as possible failure scenarios and their control measures.

15.4 General and operational availability

15.4.1 The safety, operational reliability, and dependability of a gas-fuelled engine shall be equivalent to that of a conventional oil-fuelled marine diesel engine.

15.4.2 The engine shall be capable of safe and reliable operation throughout the entire power range under all expected operation conditions.

15.4.3 Composition and minimum methane number of gas fuel supplied to the engine shall be in accordance with the engine manufacturer's specification. If gas composition or methane number exceeds specified limits, no dangerous situation shall arise.

15.4.4 General requirements regarding redundancy of essential systems (main propulsion, electrical power generation, etc.) are to be considered. The same basic requirements apply to gas-fuelled engine installations as for oil-fuelled engine installations.

15.4.5 Arrangements of the gas-fuelled installation for sustained or restored operation following blackout and dead ship condition shall be carefully evaluated.

15.4.6 Overall operational availability of the gas fuelled engine installation shall not be reduced by engine safety functions, such as automatic shutdown of external gas supply, to a level lower than achieved by oil-fuelled engine installations. Furthermore, gas leakages anywhere in the gas storage system, gas supply system, or gas engine components shall not cause automatic shutdown of other engines in order to maintain essential functions such as main propulsion power and electrical power generation.

15.4.7 For single engine main propulsion plants the entire system, including gas supply, machinery space safety concept, and gas engine design shall be evaluated with regard to operational availability and redundancies.

15.4.8 In general, dual-fuel engines suitable for change-over to oil fuel mode in case of failure in the gas supply system are considered to be the only gas fuelled engines practicable for single engine main propulsion plants.

15.5 Documents to be submitted

15.5.1 In addition to the documents defined in 2. and the Guidelines for the Use of Gas as Fuel for Ships, the documents as listed in Table 15.1 shall be submitted for approval respectively review. In specific cases and following prior agreement with ACS they can also be submitted in paper form in triplicate.

Table 15.1 Documents to be submitted for gas-fuelled engines

Item No.	Description
1	General engine concept with regard to gas as fuel (description)
2	Engine specification sheet and technical data
3	Specification of permissible fuel gas properties
4	Engine safety concept, including system FMEA with regard to gas as fuel
5	Definition of hazardous areas
6	General installation manual for the engine type with regard to machinery space layout and equipment
7	Fuel gas system for the engine, including double wall piping system and ventilation system (schematic layout, details, assembly, functional description)
8	Charge air system (schematic layout, functional description, assembly)
9	Engine exhaust gas system (schematic layout, assembly)
10	Explosion relief valves for crankcase, air intake manifold and exhaust manifold (specification, arrangement, determination of minimum number and size required, operating parameters of protected manifolds) refer also to 15.8.3.3.4
11	Engine control system (schematic layout, functional description, specification)
12	Ignition system (schematic layout, functional description, specification)
13	Combustion monitoring system (schematic layout, functional description, specification)
14	Engine monitoring system (schematic layout, functional description, specification)
15	Engine alarm and safety system (schematic layout, functional description, specification)
16	Gas detection system for the engine (schematic layout, functional description)
17	Electronic components of engine control-, ignition-, alarm-, safety-, monitoring system, etc. (specification, type approvals)
18	List of type approved equipment
19	List of explosion-proof electrical equipment incl. specification of certifications
20	Testing procedure for gas detection system
21	Testing procedure for gas tightness
22	General concept regarding training measures for operating personnel

15.6 General requirements

15.6.1 Gas supply concept

15.6.1.1 Gas-fuelled engines shall either be designed according to Emergency Shut-down Concept (ESD) or Gas Safe Concept (for the definition and requirements see the Guidelines for the Use of Gas as Fuel for Ships).

15.6.1.2 The general design principle (ESD or Gas Safe Concept) will influence the range of acceptable applications with regard to engine room arrangements, engine room safety concept, redundancy concept, propulsion plant, etc.

15.6.2 Requirements for single gas fuel engines

15.6.2.1 In general, single gas fuel engines are only considered suitable for electric power generating plants.

15.6.2.2 The application of single gas fuel engines for mechanical propeller drives requires special evaluation and consideration.

15.6.3 Requirements for dual-fuel engines

15.6.3.1 Dual-fuel engines are to be of the dual-fuel type employing pilot fuel ignition and to be capable of immediate change-over to oil fuel only.

15.6.3.2 Only oil fuel is to be used when starting the engine.

15.6.3.3 Only oil fuel is, in principle, to be used when the operation of an engine is unstable, and/or during maneuvering and port operations.

15.6.3.4 In case of shut off of the gas fuel supply or engine failure related to gas operation, engines are to be capable of continuous operation by oil fuel only.

15.6.3.5 In general, engine power and speed shall not be influenced during fuel change-over process. An automatic system shall provide for a change-over procedure with minimal fluctuations in engine power and speed.

15.6.3.6 The change-over process from gas mode to oil mode shall be possible at all operating conditions.

15.7 Systems

Requirements as specified in the Guidelines for the Use of Gas as Fuel for Ships shall be observed.

15.7.1 Cooling water system

15.7.1.1 Means are to be provided to degas the cooling water system from fuel gas if the possibility is given that fuel gas can leak directly into the cooling water system.

15.7.1.2 Suitable gas detectors are to be provided.

15.7.1.3 Flame arrestors are to be provided at the vent pipes.

15.7.2 Lubrication oil system

15.7.2.1 Means are to be provided to degas the lubrication oil system from fuel gas if the possibility is given that fuel gas can leak directly into the lubrication oil system.

15.7.2.2 Suitable gas detectors are to be provided.

15.7.2.3 Flame arrestors are to be provided at the vent pipes.

15.7.3 Fuel oil system

15.7.3.1 Means are to be provided to degas the fuel oil system from fuel gas if the possibility is given that fuel gas can leak directly into the fuel oil system.

15.7.3.2 Suitable gas detectors are to be provided.

15.7.3.3 Flame arrestors are to be provided at the vent pipes.

15.7.4 External gas supply system

15.7.4.1 The external gas supply system shall be designed such that the required gas conditions and properties (temperature, pressure, etc.) as specified by the engine maker at engine inlet are adhered to under all possible operating conditions.

15.7.4.2 Arrangements are to be made to ensure that no gas in liquid state is supplied to the engine, unless the engine is designed to operate with gas in liquid state.

15.7.4.3 In addition to the automatic shut off supply valve a manually operated valve shall be installed in series in the gas supply line to each engine.

15.7.5 Gas system on the engine

15.7.5.1 General requirements

15.7.5.1.1 Gas piping on an engine shall be designed and installed taking due account of vibrations and movements during engine operation.

15.7.5.1.2 In case of rupture of a gas pipe or excessive pressure loss, automatic shutdown of the gas supply shall be activated.

15.7.5.2 Low pressure gas supply

15.7.5.2.1 Flame arresters shall be provided in the gas supply system on the engine as determined by the system FMEA.

15.7.5.2.2 Gas admission valves shall be located directly at each cylinder inlet. In general, mixing of fuel gas with combustion air shall not take place before the cylinder inlet.

15.7.5.2.3 Gas admission by a common gas admission valve and mixing of gas with combustion air before the cylinder inlet may be acceptable subject to an acceptable level of risk being determined in the safety concept and system FMEA.

15.7.5.3 High pressure gas supply

15.7.5.3.1 Flame arresters shall be provided at the inlet to the gas supply manifold of dual-fuel engines.

15.7.5.3.2 The high pressure gas is to be blown directly into the cylinders without prior mixing with combustion air.

15.7.5.3.3 High pressure gas pipes on the engine shall be carried out in double wall design with leakage detection. The outer pipe is to be designed to withstand serious leakage of the inner high pressure pipe. Gas pressure and temperature is to be considered.

15.7.5.4 Gas admission valve

15.7.5.4.1 The gas admission valve shall be controlled by the engine control system according to the actual gas demand of the engine.

15.7.5.4.2 Uncontrolled gas admission shall be prevented by design measures or indicated by suitable detection and alarm systems. Measures to be taken following detection and alarm are to be examined as part of the system FMEA.

15.7.6 Ignition system

15.7.6.1 General requirements

Ignition systems commonly use either electrical spark plugs (single gas fuel engines) or pilot fuel oil injection (dual fuel engines).

15.7.6.1.1 The ignition system has to ensure proper ignition of the gas at all operating conditions and must be able to provide sufficient ignition energy.

15.7.6.1.2 Before starting the engine, the engine has to be ventilated without injection or supplying any fuel.

15.7.6.1.3 Before activating the gas admission to the engine, the ignition system has to be checked automatically to verify correct functioning.

15.7.6.1.4 Combustion of each cylinder is to be monitored. Misfiring and knocking combustion is to be detected.

15.7.6.1.5 Safe and reliable operation of the ignition system shall be demonstrated and documented by a system FMEA.

15.7.6.1.6 During stopping of the engine the fuel gas supply shall be shut off automatically before the ignition source.

15.7.6.2 Spark ignition

For a spark ignition engine, if ignition has not been detected on each cylinder by the engine monitoring system within an engine specific time after operation of the gas admission valve, gas supply shall be automatically shut off and the starting sequence terminated.

Any unburned gas mixture is to be purged from the exhaust system.

15.7.6.3 Ignition by pilot injection

15.7.6.3.1 Prior to admission of fuel gas the correct operation of the pilot oil injection system on each cylinder shall be verified.

15.7.6.3.2 An engine shall always be started using fuel oil only.

15.7.7 Electrical systems

15.7.7.1 Care shall be taken to prevent any possible sources of ignition caused by electrical equipment, electrical sensors, etc. installed in hazardous areas.

15.7.7.2 For electrical equipment and sensors in hazardous areas the explosion protection requirements in the ACS Rules for Electrical Installations are to be observed.

15.7.7.3 Systems that shall remain operational when the safety system triggers shut off of the gas supply are to be determined by the system FMEA. Systems to be considered shall include, but not be limited to, the ventilation system, inert gas system and gas detection system.

15.7.8 Engine control-, monitoring-, alarm-, and safety systems

15.7.8.1 General requirements

15.7.8.1.1 General requirements regarding gas supply and automatic activation of gas supply valves (double block and bleed valves, master gas valve) to the engine as defined in the Guidelines for the Use of Gas as Fuel for Ships and ACS Rules for Liquefied Gas Carriers shall be observed.

15.7.8.1.2 Knocking combustion and misfiring is to be detected and combustion conditions are to be automatically controlled to prevent knocking and misfiring.

15.7.8.1.3 The engine operating mode shall always be clearly indicated to the operating personnel.

15.7.8.1.4 Guidance for the scope of instrumentation for monitoring, alarm, and safety systems is given in Table 15.2. Depending on engine design, safety concept, and system FMEA examining all possible failure modes, deviations from Table 15.2 may be agreed.

Table 15.2: Indicative scope of instrumentation for gas-fuelled engines

	Indicator, larm, shutdown [1]	Shut off of gas supply to individual engine(double	Shut off of gas supply to machinery space (master gas valve) [1]	Comment
Gas supply				
Gas pressure	I, L,H			
Gas temperature	I, L,H			
Gas admission valve(s) failure	A, S[2]	X		incl. failure of
				sealing oil, cooling,
Pressure of inert gas supply	I,L			etc.
Rupture of gas pipe or excessive gas leakage	A,S	X	X	
Failure containment or vacuum of shielded gas	A,S [2]	X	X	
piping system				gas safe concept
Gas detection				
Gas concentration in air manifold	H			
Gas concentration in crankcase	H			
Gas concentration in exhaust manifold	H			
Gas concentration below each piston [3]	H			
Gas concentration in shielded gas piping	H,S[2]	X	X	
system	H,S	X	X	
Gas concentration in engine room				
Crankcase	H,S	X	X	
Pressure	H,S	X	X	
Temperature [4]	H,S	X	X	
Oil mist concentration				
Combustion monitoring	A,S[2]	X		
Misfiring, each cylinder	A,S[2]	X		
Knocking, each cylinder	H,L,S[2]	X		
Cylinder pressure	A,S[2]	X		
Load deviation	A,S[2]	X		
Spark ignition system or pilot injection system				
failure				
Exhaust gas	I,H			
Exhaust gas temperature turbocharger inlet and				
outlet	I,L,H,S[2]	X		
Exhaust gas temperature, each cylinder	L,H,S[2]	X		
Deviation from exhaust gas mean temperature				
Miscellaneous	A,S[2]	X		
Failure in gas combustion control system	A			
Failure ventilation of shielded gas piping	A			gas safe concept
system	A,S	X		externally or
Failure exhaust gas ventilation system				manually
Engine shutdown				activated

I : Indicator

A : Alarm

L : Alarm for lower limit

H : Alarm for upper limit

S : Shutdown

X : activation

1) In general, shut off of gas supply and engine shutdown shall not be activated at initial trigger level without pre-alarm.

2) Automatic shutdown shall be replaced by automatic change-over to fuel oil mode for dual-fuel engines subject to a continued safe operation

3) Cross-Head type engines

4) Temperature of liners and bearings

15.7.8.2 Gas detection

15.7.8.2.1 A continuous gas detection system shall be provided (see the Guidelines for the Use of Gas as Fuel for Ships).

15.7.8.2.2 The gas detection system shall be in operation as long as fuel gas is supplied to the engine.

15.7.8.2.3 As guidance, the gas detection system shall cover the spaces of the engine as specified in Table 15.2. Depending on engine design, safety concept, and system FMEA deviations from Table 15.2 may be agreed.

15.7.8.2.4 Manual gas detection may be installed in lieu of continuous gas detection for certain spaces if this is shown to be acceptable by the system FMEA.

15.7.8.3 Speed control and load acceptance

15.7.8.3.1 In general, the requirements in 6.1 shall be observed.

15.7.8.3.2 The basic requirements of 6.1.2.3 regarding design of the ship's power management system apply.

15.7.8.3.3 Exemptions from minimum required step loading capability of engines driving electrical generators as shown in Figure 6.1 can be agreed for gasfuelled engines of limited step loading capability.

15.7.9 Exhaust gas system and ventilation system

15.7.9.1 Exhaust gas pipes from gas-fuelled machinery are to be installed separately from each other, taking into account structural fire protection requirements.

15.7.9.2 Machinery, including the exhaust gas system, is to be ventilated:

- prior to each engine start,

- after starting failure,
- after each gas operation of gas-fuelled machinery not followed by an oil fuel operation.

15.7.9.3 Control of the ventilation system shall be included in the automation system. Failures shall be alarmed.

15.8 Safety equipment and safety systems

Basic requirements as specified in the ACS Guidelines for the Use of Gas as Fuel for Ships shall be observed.

15.8.1 Safety concept and system FMEA

15.8.1.1 The safety concept shall describe the safety philosophy with regard to gas as fuel and in particular address how risks associated with this type of fuel are controlled. The safety concept shall also describe possible failure scenarios and the associated control measures.

15.8.1.2 In the system FMEA possible failure modes related to gas as fuel shall be examined and evaluated in detail with respect to their consequences on the engine and the surrounding systems as well as their likelihood of occurrence and mitigating measures.

Verification tests are to be defined. Aspects to be examined include, but shall not be limited to:

- gas leakage, both engine internal and release of gas to the engine room
- shut off of gas supply (inter alia with respect to systems that shall remain operational, refer 15.7.7.3)
- incomplete/ knocking combustion
- deviation from the specified gas composition
- malfunction of the ignition system
- uncontrolled gas admission to engine
- switch over process from gas to fuel and vice versa for dual fuel engines
- explosions in crankcase, scavenging air system and exhaust gas system
- uncontrolled gas air mixing process, if outside cylinder
- interfaces to other ship systems, e.g. control system, gas supply

15.8.2 Crankcase safety equipment

15.8.2.1 Piston failure

Piston failure and abnormal piston blow-by shall be detected and alarmed.

15.8.2.2 Crankcase

15.8.2.2.1 Crankcase venting pipes are to be equipped with flame arrestors.

15.8.2.2.2 A detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase is to be carried out and included in the safety concept (see 15.8.1).

15.8.2.3 Removal of fuel gas from crankcase and inert gas injection

15.8.2.3.1 Means shall be provided to measure the fuel gas concentration in the crankcase.

15.8.2.3.2 Suitable measures, such as inert gas injection, shall be provided to remove fuel gas – air mixtures from the crankcase at engine standstill.

15.8.2.3.3 Suitable means shall be available to purge inert gas from the crankcase before opening the crankcase for maintenance.

15.8.2.3.4 Signs requiring a fuel and inert gas free atmosphere in the crankcase before Opening of crankcase doors shall be placed in conspicuous locations.

Note:

Means for automatic injection of inert gas into the crankcase are recommended, e.g. in case of:

– engine emergency shutdown
– oil mist detection as well as bearing and liner temperature alarm
– fire detection in engine room

15.8.3 Explosion relief valves

15.8.3.1 General requirements

15.8.3.1.1 Explosion relief devices shall close firmly after an explosion event.

15.8.3.1.2 The outlet of explosion relief devices shall discharge to a safe location remote from any source of ignition. The arrangement shall minimize the risk of injury to personnel.

15.8.3.2 Crankcase explosion relief valves

15.8.3.2.1 For crankcase safety devices (e.g. explosion relief valves, oil mist detection, etc.) the requirements specified in 6.4. are to be observed.

15.8.3.2.2 Crankcase explosion relief valves are to be provided at each crank throw.

15.8.3.2.3 The minimum required total relief area of crankcase explosion relief valves is to be evaluated by engine maker considering explosions of fuel gas –air mixtures and oil mist.

15.8.3.3 Other explosion relief valves

15.8.3.3.1 As far as required in the Guidelines for the Use of Gas as Fuel for Ships, explosion relief valves are to be provided for combustion air inlet manifolds and exhaust manifolds.

15.8.3.3.2 Explosion relief valve shall generally be approved by ACS for the application on inlet manifolds and exhaust manifolds of gas-fuelled engines.

15.8.3.3.3 For the approval of relief valves the following documentation is to be submitted (usually by the maker of explosion relief valve):

- drawings of explosion relief valve (sectional drawings, details, assembly, etc.)
- specification data sheet of explosion relief valve (incl. specification of operating conditions such as max. working pressure, max. working temperature, opening pressure, effective relief area, etc.)
- test reports

15.8.3.3.4 In addition to the approval under 15.8.3.3.3 the arrangement of explosion relief valves shall be approved for each engine type. The following documents are to be submitted (usually by the engine manufacturer):

- drawing of arrangement of explosion relief valves (incl. number, type, locations, etc.)
- drawings of protected component (air inlet manifold, exhaust manifold, etc.) (incl. specification of max. working pressure, max. working temperature, max. permissible explosion pressure, etc.)
- evidence for effectiveness of flame arrestor at actual arrangement
- evidence for effectiveness of pressure relief at explosion (sufficient relief velocity, sufficient relief pressure)

Note:

Evidence can be provided by suitable tests or by theoretical analysis.

15.9. Tests

15.9.1 Type approval test for gas-fuelled engines

15.9.1.1 Gas-fuelled engines shall be type approved by ACS.

15.9.1.2 The scope of type approval testing stated in 5.4. applies as far as pertinent also to gas-fuelled engines. Additional or differing requirements reflecting gas specific aspects are listed below. The type test program is to be agreed with ACS.

15.9.1.3 Tests:

- load acceptance test and load cut off
- fuel change-over procedures (for dual fuel engines)
- combustion monitoring
- safety system

- alarm system
- monitoring system
- control system
- gas detection
- tightness tests of gas piping and double wall pipes and ducts
- ignition system
- automatic gas shut off
- turbocharger waste gate, by-pass, etc.
- ventilation system
- start, stop, emergency stop
- verification tests resulting from the system FMEA

15.9.2 Works trials

In addition to the requirements of 5.5., the following items shall be tested during works trials of gasfuelled engines:

- tightness test of gas system
- testing of systems for combustion monitoring
- testing of gas shut off and fuel change-over (dual-fuel engines) procedures

15.9.3 Shipboard trials

In addition to the requirements of 5.6., during shipboard trials the following items shall be tested:

- tightness test of gas system
- testing of systems for combustion monitoring
- testing of gas shut off and fuel change-over (dual-fuel engines) procedures
- testing of ventilation systems and gas detection systems

15.10 Machinery spaces

15.10.1 Sufficient air exchange and air flow shall be ensured around the engine to prevent accumulation of explosive, flammable, or toxic gas concentrations.

15.10.2 Direction of air flow in machinery spaces shall be directed in such way as to avoid flow of any leaking gas towards potential sources of ignition.

15.10.3 Machinery spaces shall have sufficient openings to the outside to allow pressure relief from the machinery space in case of an explosion event inside a gas-fuelled engine installed in the space.

15.10.4 Sign plates shall be fixed at adequate locations to make notice of gas-fuelled Machinery to persons entering the relevant machinery spaces. Instructions regarding operation as well as behaviour in case of gas leaks and failure of machinery are to be provided at prominent positions in machinery spaces.

15.11 Training

Personnel operating gas-fuelled engines aboard a vessel shall be duly trained regarding operation of the specific engine, gas supply systems, safety- and control systems, etc. installed on the vessel.

15.12 Spare parts

Spare parts, which are of major importance for the safety and operational reliability of the gas-fuelled engine, as well as parts with limited lifetime, shall be provided on board in addition to those required in Section 16.

15.13 Retrofit

Acceptance criteria and procedure for conversion of existing oil-fuelled diesel engines into gas-fuelled or dual-fuel engines are to be individually agreed with ACS.

Section 3 Turbomachinery / Steam Turbines

1 General

1.1 Scope

The following Rules apply to main and auxiliary steam turbines.

ACS reserve the right to authorize deviations from the requirements in the case of low-power turbines.

1.2 Documents for approval

For every steam turbine installation, the documents listed below are to be submitted to ACS. In specific cases and following prior agreement with ACS they can also be submitted in paper form in triplicate for approval.

- assembly and sectional drawings of the turbines
- detail drawings of rotors, casings, guide blading, blades, valves, bed frames and main condenser (for gearing, see Section 6)
- details of operating characteristics and critical speeds
- proof of a sufficient safety margin in the components subject to the severest loads; for temperatures up to approximately 400 °C, the relevant strength characteristic is the yield point at elevated temperatures; for higher temperatures it is the long-term creep strength for 100000 hours at service temperature
- details of the welding conditions applicable to welded components
- on request, calculations relating to blade vibration

For small auxiliary turbines with a steam inlet temperature of up to 250 °C it is generally sufficient to submit sectional drawings of the turbines.

Heat flow diagrams for each turbine installation and a set of operating instructions for at least each turbine type are to be submitted.

2 Materials

2.1 Approved materials

2.1.1 Rotating components

Turbine rotors, discs and shafts are to be manufactured from forged steel.

The rotors of small turbines may also be cast in special grade steel. Turbine blades, shrouds, binding and damping wires are to be made of corrosion-resistant materials.

2.1.2 Stationary components

The casings of high-pressure turbines and the bodies of maneuvering, quick-closing and throttle valves are to be made of high-temperature steel or cast steel.

Depending upon pressure and temperature, the casings of intermediate and low-pressure turbines may also be made of nodular or grey cast iron.

Diaphragms (guide vanes) are to be manufactured from steel, cast steel, nodular or grey cast iron depending on the temperature and load. Welded construction may also be approved for steel or cast steel components.

Grey and nodular cast iron may be used up to a steam temperature of 300 °C.

2.2 Testing of materials

2.2.1 The following parts are subject to testing in accordance with ACS Rules Part II – Materials and Welding:

- rotating parts such as rotors, discs, shafts, shrink rings, blades, toothed couplings and other dynamically loaded components as well as valve spindles and cones
- stationary parts such as casings, guide blading, nozzles and nozzle chests, guide vanes, turbine casing bolts, bed frames and bearing pedestals
- condenser tubes and tube plates

In the case of small auxiliary turbines with a steam inlet temperature of up to 250 °C, the extent of the tests may be limited to the disc and shaft materials.

3 Design and Construction Principles

3.1 Foundations

The foundations of geared turbine installations are to be so designed and constructed that only minor relative movements can occur between the turbine and the gearing which can be compensated by suitable couplings.

3.2 Jointing of mating surfaces

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

3.3 Bearing lubrication

The lubrication of bearings are not to be impaired by adjacent hot parts or by steam.

For the lubricating oil system, see Section 11.

3.4 Connections

Pipes are to be connected to the turbine in such a way that no unacceptably high forces or moments can be transmitted to the turbine.

3.5 Drains

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

3.6 Turning gear

Main propulsion turbines are to be equipped with turning gear for both directions of rotation. The rotors of auxiliary turbines are at least to be capable of being turned by hand.

3.7 Measurement of rotor clearances

After assembly of each turbine in the manufacturer's works, the rotor position and the clearances are to be determined. The clearances are to be specified in the operating instructions.

3.8 Vibrations

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

The assessment may be based on ISO 10816-3 "Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts" or an equivalent standard.

4 Astern Running, Emergency Operation

4.1 Astern power for main propulsion

4.1.1 The main propulsion machinery is to possess sufficient power for running astern. The astern power is considered to be sufficient if, given free running astern, it is able to attain astern revolutions equivalent to at least 70 % of the rated ahead revolutions for a period of at least 30 minutes.

4.1.2 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.

4.2 Arrangements for emergency operation

In single screw ships fitted with cross compound steam turbines, the arrangements are to be such as to enable safe operation when the steam supply to any one of the turbines is isolated. For this emergency operation purpose the steam may be led directly to the lower pressure turbine and either the high or medium pressure part may exhaust directly to the condenser.

Adequate arrangements and controls are to be provided for these operating conditions so that the pressure and temperature of the steam will not exceed those which the turbines and condenser are designed for, thus enabling a long term safe operation under emergency conditions.

The necessary pipes and valves for these arrangements are to be readily available and properly marked. A fit up test of all combinations of pipes and valves is to be presented to ACS prior to the first sea trials.

The permissible operating conditions (power/speeds) when operating without one of the turbines (all combinations) are to be specified and accessibly documented on board.

The operation of the turbines under emergency conditions is to be assessed by calculations for the potential influence on shaft alignment and gear teeth loading conditions. Corresponding documentation shall be submitted to ACS for appraisal.

5 Maneuvering and Safety Equipment

5.1 Maneuvering and control equipment

5.1.1 The simultaneous admission of steam to the ahead and astern turbines is to be prevented by interlocks.

Brief overlapping of the ahead and astern valves during manoeuvring can be allowed.

5.1.2 Fluids for operating maneuvering equipment, quick-closing and control systems are to be suitable for all service temperatures and of low flammability.

5.1.3 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.

5.1.4 The speed increase of turbines driving electric generators - except those for electrical propeller drive - resulting from a change from full load to noload may not 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 may not exceed 10 % and is to be separated by a sufficient margin from the trip speed.

5.2. Safety devices

5.2.1 Main propulsion turbines are to be equipped with quick-closing devices which automatically shutoff the steam supply in case of:

a) overspeed. Excess speeds of more than 15 % above the rated value are to be prevented

b) unacceptable axial displacement of the rotor

c) an unacceptable increase in the condenser pressure

d) an unacceptable increase in the condenser water level and

e) an unacceptable drop in the lubricating oil pressure

5.2.2 In cases a) and b) of 5.2.1, the quick-closing devices shall be actuated by the turbine shafts.

5.2.3 It also is to be possible to trip the quick closing device manually at the turbine and from the control platform.

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

5.2.5 It is recommended that an alarm system should be fitted which responds to excessive vibration velocities.

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

5.2.7 Steam bleeder and pass-in lines are to be fitted with automatic devices which prevent steam from flowing into the turbine when the main steam admission valve is closed.

5.2.8 Turbines driving auxiliary machines at least are to be equipped with quick-closing devices for contingencies a) and d) of 5.2.1. An excessive rise in the exhaust steam pressure is to actuate the quick-closing device.

5.2.9 It shall be possible to start up any turbine only when the quick-closing device is ready for operation.

5.3 Other requirements

Depending on the degree of automation involved, the extent and design of the equipment is also subject to the requirements in ACS Rules for Automation.

6 Control and Monitoring Equipment

6.1 Arrangement

The control and monitoring equipment for each main propulsion unit is to be located on the control platform.

6.2 Scope and design of equipment

Depending on the degree of automation involved, the scope and design of the equipment is also subject to the Rules in ACS Rules for Automation, Ch. 3.

6.3 Control and indicating instruments

When the turning gear is engaged, this fact is to be indicated visually at the control platform.

Turbine and pipeline drainage valves are either to operate automatically or are to be combined into groups which can be operated from the control platform.

6.4 Equipment for auxiliary turbines

Turbines driving auxiliary machines are to be provided with the necessary equipment on the basis of 6.2. and 6.3.

7 Condensers

7.1 Design

The condenser is to be so designed that the inlet steam speed does not result in prohibitive stressing of the condenser tubes. Excessive sagging of the tubes and vibration are to be avoided, e.g. by the incorporation of tube supporting plates.

The water chambers and steam space are to be provided with openings for inspection and cleaning. Anticorrosion protection is to be provided on the water side.

In the case of single-plane turbine installations, suitable measures are to be taken to prevent condensate from flowing back into the low pressure turbine.

7.2 Cooling water supply

The supply of cooling water to the condenser is subject to the requirements contained in Section 11.

8 Tests

8.1 Testing of turbine rotors

8.1.1 Thermal stability test

Rotors forged in one piece and welded rotors are to be tested for axial stability by submitting them to a thermal stability test.

8.1.2 Balancing

Finished rotors, complete with blades and associated rotating parts and ready for assembly, are to be dynamically balanced in the presence of the Surveyor.

The assessment may be based on ISO 1940-1 standard "Mechanical vibration – Balance quality requirements of rigid rotors" or an equivalent standard.

8.1.3 Cold over speed test

Turbine rotors are to be tested at a speed at least 15 % above the rated speed for not less than three minutes.

ACS may accept mathematical proof of the stresses in the rotating parts at over speed as a substitute for the over speed test itself, provided that the design is such that reliable calculations are possible and the rotor has been non-destructively tested to ascertain its freedom from defects.

8.2. Pressure and tightness tests

8.2.1 All finished casing components are to be subjected to hydrostatic testing in the presence of the Surveyor.

The test pressure pp is calculated as follows:

where $p_{e,zul} \leq 80$ bar: $p_p = 1.5\ p_{e,zul}$

where $p_{e,zul} > 80$ bar: $p_p = p_{e,zul} + 40$ bar

$p_{e,zul}$ = maximum allowable working pressure [bar]

For the bodies of quick-closing, manoeuvring and control valves, the test pressure is 1.5 times the maximum allowable working pressure of the boiler (approval pressure). The sealing efficiency of these valves when closed is to be tested at 1.1 $p_{e,zul}$.

8.2.2 Casing parts on the exhaust side of low pressure turbines subjected during operation to the condenser pressure are to be tested at pp = 1.0 bar.

8.2.3 Condensers are to be subjected to separate hydrostatic testing on both the steam and the water side. The test pressure pp shall be:

p_p = 1.0 bar on the steam side

$p_p = 1.5\ p_{e,zul}$ on the water side

9 Trials

9.1 Factory trials

Where steam turbines are subjected to a trial run at the factory, the satisfactory functioning of the manoeuvring, safety and control equipment is to be verified during the trial run, and such verification shall in any case take place not later than the commissioning of the plant aboard ship.

9.2 Shipboard trials

9.2.1 Main turbines are to be subjected to a dock trial and thereafter, during a trial voyage, to the following tests:

- operation at rated rpm for at least 6 hours
- reversing manoeuvres

- during the dock or sea trials, astern revolutions equal to at least 70 % of the rated ahead rpm for about 20 minutes.

During astern and subsequent forward operation, the steam pressures and temperatures and the relative expansion are not to reach magnitudes liable to endanger the operational safety of the plant.

9.2.2 Turbines driving electric generators or auxiliary machines are to be run for at least 4 hours at their rated power and for 30 minutes at 110 % rated power.

Section 4 Turbomachinery/ Gas Turbines and Exhaust Gas Turbochargers

Gas Turbines

The documents for approval of main and auxiliary gas turbines have to be submitted to ACS Head Office. The approval will be performed in accordance with ACS Head Office.

Exhaust Gas Turbochargers

1 General

1.1 Application

These Rules are applicable for approval of turbochargers fitted on diesel engines and describe the required procedures for drawing approval, testing and shop approval.

1.2 Definitions

Regarding turbocharger speed conditions, the following definitions are to be applied:

- maximum permissible speed:
- maximum turbocharger speed, independent of application.
- maximum operational speed:
- speed at 110 % diesel engine output.
- operational speed:
- speed at 100 % diesel engine output (Maximum Continuous Rating (MCR) condition).

The maximum operational speed and maximum permissible speed may be equal.

1.3 Type approval

In general turbochargers are type approved. A Type Certificate valid for 1 year will be issued in accordance with 1.3.1.

1.3.1 Documentation to be submitted

For every turbocharger type, the documents listed below are to be submitted to ACS. In specific cases and following prior agreement with ACS they can also be submitted in paper form in triplicate.

- cross-sectional drawings with main dimensions
- drawings of rotating parts (shaft, turbine wheel, compressor wheel, blades) and details of blade fixing
- arrangement and flow diagram of lubrication system
- material specifications including the mechanical and chemical properties for the rotating parts (shaft, turbine wheel, compressor wheel, blades) and the casing including welding details and welding procedures for the rotating parts
- technical specification for the turbocharger including maximum continuous operating conditions (maximum permissible values for the rotational speed, exhaust gas and ambient temperature as well as the permissible values regarding vibration excited by

the engine). The maximum permissible values have to be defined by the manufacturer for a certain turbocharger type but shall be not less than the 110 % MCR values for the specific application.

- operation and maintenance manuals
- details (name and address) of the subcontractors for rotating parts and casings
- details (name and address) of the licensees, if applicable, who are authorized by the licensor to produce and deliver turbochargers of a certain type
- type test report carried out in accordance with 3.8.
- test report or verification by calculation of the containment test, carried out in accordance with 3.7.

2 Design and Installation

2.1 General

Turbochargers are to be designed to operate at least under the ambient conditions given in Section 1.3.

2.2 Basic design considerations

Basis of acceptance and subsequent certification of a turbocharger is the drawing approval and the documented type test as well as the verification of the containment integrity.

The turbocharger rotors need to be designed according to the criteria for natural burst speed. In general the burst speed of the turbine shall be lower than the burst speed of the compressor in order to avoid an excessive turbine over speed after compressor burst due to loss of energy absorption in the compressor.

2.3 Air inlet

The air inlet of the turbocharger is to be fitted with a filter in order to minimize the entrance of dirt or water.

2.4 Hot surfaces

According to SOLAS Rules and Regulations, Chapter II-2, Part B – Prevention of fire and explosion, Regulation 4, Paragraph 2.2.6, parts with surface temperatures above 220 °C are to be properly insulated in order to minimize the risk of fire if flammable oils, lubrication oils, or fuel come into contact with these surfaces.

Pipe connections have to be located or shielded with collars in such a way that either spraying or dripping leak oil may not come into contact with hot surfaces of more than 220 °C.

Hot components in range of passageways or within the working area of turbochargers shall be insulated or protected so that touching does not cause burns.

2.5 Bearing lubrication

Bearing lubrication shall not be impaired by exhaust gases or by adjacent hot components.

Leakage oil and oil vapours are to be evacuated in such a way that they do not come into contact with parts at temperatures equal or above their self-ignition temperature.

For turbochargers which share a common lubrication system with the diesel engine and which have got an electrical lubrication oil pump supply, it is recommended to install an emergency lubrication oil tank.

A gas flow from turbocharger to adjacent components containing explosive gases, e.g. crankshaft casing shall be prevented by an adequate ventilating system.

3 Tests

3.1 Material tests

3.1.1 General

Material testing is required for casings, shaft, compressor and turbine wheel, including the blades. The materials used for the components of exhaust gas turbochargers shall be suitable for the intended purpose and shall satisfy the minimum requirements of the approved manufacturer's specification.

All materials shall be manufactured by sufficiently proven techniques according to state of the art, whereby it is ensured that the required properties are achieved. Where new technologies are applied, a preliminary proof of their suitability is to be submitted to ACS. According to the decision of ACS, this may be done in terms of special tests for procedures and/or by presentation of the work's own test results as well as by expertises of independent testing bodies.

The turbocharger casings are to be from ductile materials (minimum 90% ferritic structure) and properly heat-treated in order to achieve the required microstructure and ductility as well as to remove residual stresses. Deviations from the standard heat-treatment have to be approved separately by ACS.

3.1.2 Condition of supply and heat treatment

Materials are to be supplied in the prescribed heat treated condition. Where the final heat treatment is to be performed by the supplier, the actual condition in which the material is supplied shall be clearly stated in the relevant Certificate. The final verification of material properties for components needs to be adapted and coordinated according to production procedure. Deviations from the heat treatment procedures have to be approved by ACS separately.

3.1.3 Chemical composition and mechanical properties

Materials and products have to satisfy the requirements relating to chemical composition and mechanical properties specified in the ACS Rules Part II – Materials and Welding, Metallic Materials or, where applicable, in the relevant manufacturer's specifications approved for the type in each case.

3.1.4 Non-destructive testing

Non-destructive testing shall be applied for the wheels, blades and welded joints of rotating parts. Another equal production control may be accepted for welded joints. The testing shall be performed by the manufacturer and the results together with details of the test method are to be evaluated according to recognized quality criteria and documented in a Certificate.

3.1.5 Material Certificates

Material Certificates shall contain at least the following information:

- quantity, type of product, dimensions where applicable, types of material, supply condition and weight
- name of supplier together with order and job numbers, if applicable
- construction number, where known
- manufacturing process
- heat numbers and chemical composition
- supply condition with details of heat treatment
- identifying marks
- results of mechanical property tests carried out on material at ambient temperature Depending on the produced component of turbocharger material Certificates are to be issued by ACS respectively the manufacturer. The required Certificates are summarized in Table3.1.

Table 3.1: Material Certificates

Turbocharger components	Type of Certificate [1]
Shaft	ACS Material Certificate
Rotors(compressor and turbine)	ACS Material Certificate
Blades	ACS Material Certificate
Casing	Manufacturer Test Report

1) Test Certificates are to be issued in accordance with ACS Rules Part 2 – Materials and Welding, Chapter 2, Mechanical Testing Procedures.

The materials are to conform to specifications approved in connection with the approval of the type in each case.

If the manufacturer is approved according to 4.2. as manufacturer of mass produced exhaust gas turbochargers fitted on diesel engines having a cylinder bore ≤ 300 mm, the material properties of these parts may be covered by Manufacturer Inspection Certificates and need not to be verified by a ACS Surveyor.

3.2 Testing of components

The following tests as outlined in 3.3 – 3.5 may be carried out and certified by the manufacturer for all exhaust gas turbochargers. The identification of components subject to testing has to be ensured. On request, the documentation of the tests, including those of subcontractors' tests, are to be provided to the ACS Surveyor for examination.

The tests as specified in 3.6 – 3.8 are to be performed in presence of a ACS Surveyor.

ACS reserve the right to review the proper performance and the results of the tests at any time to the satisfaction of the Surveyor.

3.3 Pressure tests

Cooling water spaces as well as the emergency lubrication oil system for gas inlet and gas outlet casings are to be subjected to a hydrostatic pressure test of pp = 4 bar, but not less than pp = 1.5 pc (pp = test pressure; pc = design pressure).

3.4 Over speed test

All wheels (compressor and turbine) have to undergo an over speed test for 3 minutes at 20 % over the maximum operational speed at room temperature, or 10 % over the maximum permissible speed at maximum permissible working temperature. If each wheel is individually checked by a ACS approved non-destructive testing method no over speed test is required. Deviations are to be approved separately by ACS.

3.5 Dynamic balancing

Each shaft and bladed wheel as well as the complete rotating assembly has to be dynamically balanced individually in accordance with the approved quality control procedure. For assessment of the balancing conditions the DIN ISO 1940 standard or comparable regulations may be referred to.

3.6 Bench test

Each turbocharger has to pass a test run.

The test run is to be carried out during 20 minutes with an overload (110 % of the rated diesel engine output) on the engine for which the turbocharger is intended.

This test run may be replaced by a separate test run of the turbocharger unit for 20 minutes at maximum operational speed and working temperature.

In case of sufficient verification of the turbocharger's performance during the test, a subsequent dismantling is required only in case of abnormalities such as high vibrations or excessive noise or other deviations of operational parameters such as temperatures, speed, pressures to the expected operational data.

On the other hand turbochargers shall be presented to the ACS Surveyor for inspection based upon an agreed spot check basis.

If the manufacturer is approved as a manufacturer of mass produced turbochargers according to 4.2., the bench test can be carried out on an agreed sample basis. In this case the surveyor's attendance at the test is not required.

3.7 Containment test

The turbocharger has to fulfill containment requirements in case of rotor burst.

This requires that at rotor burst no part may penetrate the casing of the turbocharger.

The following requirements are applicable for an approval of the type of turbochargers.

The minimum speeds for the containment test are defined as follows:

Compressor: $\geq$ 120 % of its maximum permissible speed

Turbine: $\geq$ 140 % of its maximum permissible speed or the natural burst speed (whichever is lower)

The containment test has to be performed at working temperature.

The theoretical (design) natural burst speeds of compressor and turbine have to be submitted for information.

A numerical prove of sufficient containment integrity of the casing based on calculations by means of a simulation model may be accepted, provided that:

- the numerical simulation model has been tested and it's applicability/accuracy has been proven by direct comparison between calculation results and practical containment test for a reference application (reference containment test). This proof has to be provided once by the manufacturer who wants to apply for acceptance of numerical simulation
- the corresponding numerical simulation for the containment is performed for the same speeds, as specified for the containment test (see above)
- the design of the turbocharger regarding the geometry and kinematics is similar to that of one turbocharger which has passed the containment test. In general totally new designs will call for new containment tests
- the application of the simulation model may give hints that containment speeds lower as above specified may be more critical for the casing's integrity, due to special design features and different kinematic behaviour. In such cases the integrity properties of containment for the casing shall be proven for the worst case

In general a ACS Surveyor or the Head Office has to be involved for the containment test. The documentation of the physical containment test as well as the report of the simulation results are to be submitted to ACS within the scope of the approval procedure.

3.8 Type test

The type test is to be carried out on a standard turbocharger.

Normally the type test is a one hour hot running test at maximum permissible speed and maximum permissible temperature. After the test the turbocharger is to be dismantled and examined.

Manufacturers who have facilities to test the turbocharger on a diesel engine for which the turbocharger is to be approved, may consider to substitute the hot running test by a one hour test run at overload (110 % of the rated diesel engine output).

3.9 Spare parts

The rotating assembly parts (rotor, wheels and blades) as well as turbocharger casings have to be replaced by spare parts which are manufactured by ACS approved manufacturers according to the previously approved drawings and material specifications. The manufacturer is to be recognized by the holder of the original type approval.

4 Shop Approvals

4.1 Materials and Production

The manufacturers of the material as well as the production procedures for the rotating parts and casings have to be approved by ACS.

4.2 Mass produced exhaust gas turbochargers

Manufacturers of mass-produced turbochargers who operate a quality management system and are manufacturing exhaust gas turbochargers fitted on ACS approved mass produced diesel engines having a cylinder bore of ≤ 300 mm may apply for the shop approval by ACS Head Office.

Upon satisfactory shop approval, the material tests according to 3.1 for these parts may be covered by a Manufacturer Inspection Certificate and need not to be verified by a Surveyor.

In addition the bench test according to 3.6. may be carried out on a sample basis and need not to be verified by a ACS Surveyor.

The shop approval is valid for 3 years with annual follow up audits.

No ACS Certificate will be issued for mass-produced turbochargers. Mass-produced turbochargers will be mentioned with the serial number in the final Certificate intended for the diesel engine.

4.3 Manufacturing of exhaust gas turbochargers under license agreement

Manufacturers who are manufacturing exhaust gas turbochargers under a license agreement shall have a shop recognition of ACS Head Office.

The shop recognition can be issued in addition to a valid license agreement if the following requirements are fulfilled:

- The manufactured turbochargers have a valid ACS approval of the type for the licensor.
- The drawings and the material specification as well as the working procedures comply with the drawings and specifications approved in connection with the turbocharger approval of the type for the licensor.

Upon satisfactory assessment in combination with a bench test carried out on a sample basis with ACS Surveyor's attendance, the drawing approval and tests according to 3.7 and 3.8 are not required. The scope of the testing for materials and components has to be fulfilled unchanged according to 3.1 to 3.6.

The shop recognition is valid for three years with annual follow up audits and can be granted, if required in combination with an approval as manufacturer of mass-produced turbochargers.

The shop recognition becomes invalid if the license agreement expires. The licensor is obliged to inform the ACS Head Office about the date of expiry.

Section 5 Boilers, Pressure Vessels and Heat Exchangers,

1 General Requirements

Depending on the design and parameters, boilers, pressure vessels and heat exchangers are divided into classes as indicated in Table 1.1.

Table 1.1

Kind of equipment	Class I	Class II	Class III
Steam boilers, including exhaust gas heated economizer for water temperature over 115°C, steam superheaters and steam reservoirs, thermal oil heaters	$p > 0.35$	$p \leq 0.35$	–
Steam-heated steam generators	$p > 1.6$	$p \leq 1.6$	–
Pressure vessels and heat exchangers	$p > 4.0$ or $t > 350$ or $s > 35$	$1.6 < p \leq 4.0$ or $120 < t \leq 350$ or $16 < s \leq 35$	$p \leq 1.6$ or $t \leq 120$ or $s \leq 16$
Pressure vessels and heat exchangers containing toxic, inflammable or explosive media	irrespective of parameters	–	–

p – design pressure, [MPa];

t – design wall temperature, [oC];

s – wall thickness, [mm].

2 Strength Calculations

2.1 General Requirements

2.1.1 Wall thicknesses determined by calculation are the lowest permissible values under normal operating conditions. The formulae and strength calculation methods do not take into account the manufacturer's tolerances for thickness and these shall be added as special allowances to the design thickness values.

Additional stresses due to external loads (axial forces, bending moments, torques) imposed on the calculated parts (particularly loads due to dead mass or the mass of attached parts) shall be taken into account on ACS' request.

2.1.2 The dimensions of structural components of boilers, pressure vessels and heat exchangers for which no strength calculation methods are given in this Part of the Rules shall be determined on the basis of experimental data and recognized theoretical calculations, and are subject to special consideration by ACS in each particular case.

2.2 Design Pressure

2.2.1 Where hydrostatic pressure is greater than 0.05 MPa, the design pressure shall be increased by that value.

2.2.2 For uniflow and forced-circulation boilers the design pressure shall be determined taking account of the hydrodynamic resistance in boiler components at the rated capacity.

2.2.3 For flat walls subjected to pressure from both sides, the design pressure shall be taken as the greatest of the acting pressures. Walls in the form of curved surfaces which are subjected to pressure from both sides shall be calculated for the greatest outer and inner pressures. If the pressure on one side of the flat wall or the wall in the form of curved surface is lower than the atmospheric pressure, than the maximum pressure on the other side of the wall increased by 0.1 MPa shall be taken as the design pressure.

2.2.4 The design pressure for economizers shall be taken equal to the total sum of the working pressure in the steam manifold and the hydrodynamic resistance in the economizer, piping as well as valves and fittings at boiler rated capacity.

2.3 Design Temperature

2.3.1 For the purpose of determining the allowable stresses depending on the temperature of the medium and heating conditions, the design wall temperature shall not be taken lower than indicated in Table 2.1

Table 2.1

Item	Components of boilers, pressure vessels and heat exchangers and operating conditions thereof	Design wall temperature
1	Components exposed to radiant heat	
1.1	Boiler tubes	$T_m + 50\ ^oC$
1.2	Economizer tubes	$T_m + 50\ ^oC$
1.3	Corrugated furnaces	$T_m + 75\ ^oC$
1.4	Plain furnaces, headers, chambers, combustion chambers	$T_m + 90\ ^oC$
2	Components exposed to hot gases, protected from radiant heat[1)]	
2.1	Ring segments, ends, headers, chambers, tube plates and tubes	$T_m + 30\ ^oC$
2.2	Headers and tubes of steam superheaters at steam temperature up to 400 ^oC	$T_m + 35\ ^oC$
2.3	Headers and tubes of steam superheaters at steam temperature above 400 ^oC	$T_m + 50\ ^oC$
2.4	Utilization boilers with mechanical cleaning of heated surface	$T_m + 30\ ^oC$
2.5	Utilization boilers with burner for burning out the contamination of heated surface	T_v
3	Components heated with steam or liquid	T_v
4	Not heated components[2)]	T_m

Notes:

1) – see paragraph 2.3.4;

2) – see paragraph 2.3.3;

T_m – maximum temperature of heated medium, [◦ C];

T_v – maximum temperature of heating medium, [◦C].

2.3.2 Design temperature for steam superheater tubes at steam temperatures over 400° C, as well as for tubes and manifolds of superheaters exposed to radiant heat shall be determined by calculation and is subject to ACS acceptance in each particular case.

2.3.3 A wall is considered to be non-heated if one of the following conditions is fulfilled:

- the wall is separated from the furnace or uptake by fire-resisting insulation and the distance between the wall and insulation is 300 mm or more;
- the walls is covered with fire-resisting insulation not exposed to radiant heat.

2.3.4 A wall is considered to be protected from radiant heat effect if one of the following conditions is fulfilled:

- the wall is covered with fire-resistant insulation;
- the wall is shielded by a closely spaced row of tubes (with a maximum clearance between the tubes in the row not exceeding 3 mm);
- the wall is shielded by two staggered rows of tubes with a longitudinal pitch equal to the maximum of two outside tube diameters or by three or more staggered rows of tubes with a longitudinal pitch not exceeding 2.5 times the outside tube diameter.

2.3.5 The design temperature of heated boiler walls and non-heated steam space walls of boilers shall be taken not less than 250° C.

2.3.6 Non insulated boiler walls, exceeding 20 mm in thickness, heated by hot gas, may be used only at gas temperature up to 800° C. If, with wall thickness of less than 20 mm and hot gas temperature running higher than 800° C, there are areas unprotected by insulation or by tube rows, exceeding in length 8 tube diameters, the design wall temperature shall be determined by thermal stress analysis.

2.3.7 Design temperature for tank walls and pressure vessel walls operating under refrigerant pressure shall be taken equal to 20° C, if higher temperatures are not likely to occur.

2.4 Strength Characteristics of Materials and Allowable Stresses

2.4.1 For steels with $(R_e/R_m) \leq 0.6$, the strength characteristics shall be taken equal to physical yield point or proof stress R^t_e or $R^t_{0.2}$, as well as average creep strength $R_{z/100\,000/t}$ after 105 h, at design temperature t.

For steels with $(R_e/R_m) > 0.6$, R_m , tensile strength at design temperature t shall also be taken into account.

For steel loaded in the creep conditions (temperature exceeding 450° C), irrespective of (R_e/R_m) ratio, average creep strength $R_{1/100\,000/t}$ with 1% permanent elongation, after 100 000 h, at design temperature t, shall be taken into account.

The minimum values of R^t_e , $R^t_{0.2}$ and R^t_m and average values of $R_{1/100\,000/t}$ and $R_{z/100\,000/t}$ shall be taken for calculations.

2.4.2 For materials whose stress-strain curve does not show a specific yield stress, the tensile strength at the design temperature shall be taken for calculations.

2.4.3 For cast iron and non-ferrous alloys, the minimum value of ultimate tensile strength at normal temperature shall be taken for calculations.

2.4.4 When using non-ferrous materials and their alloys, it shall be taken into account that the heating during processing and welding reduces the strengthening effect achieved by cold processing. Therefore the strength characteristics to be used for strength calculations of the components and assemblies made of such materials shall be those applicable to their annealed condition.

2.4.5 Allowable stresses σ assumed for strength calculations shall be determined as the minimum out of the following three values:

where:

$$\sigma = \frac{R_m^t}{\eta_m},\ \sigma = \frac{R_e^t}{\eta_e} \text{ or } \sigma = \frac{R_{0.2}^t}{\eta_e},\ \sigma = \frac{R_{z/100000/t}}{\eta_z},\ \sigma = \frac{R_{1/100000/t}}{\eta_p}$$

η_m – safety factor for tensile strength R_m^t ;

η_z – safety factor for creep strength $R_{z/1000000/t}$;

η_e – safety factor for yield point R_e^t i $R_{0.2}^t$;

η_p – safety factor for creep point, $R_{1/100\,000/t}$.

For values of factors – see 2.5.

2.5 Safety Factors

2.5.1 For components made of steel forgings or rolled steel, subjected to internal pressure, the safety factors shall not be less than:

$\eta_e = \eta_z = 1.6$; $\eta_m = 2.7$ and $\eta_p = 1.0$.

For components subjected to external pressure, safety factors η_e, η_z and η_m shall be increased by 20%.

2.5.2 For components of boilers, heat exchangers and pressure vessels of Class II and Class III, made of steels with $(Re/Rm) \leq 0.6$, the safety factors may be reduced, however they shall not be less than:

$\eta_e = \eta_z = 1.5$; $\eta_m = 2.6$.

2.5.3 For components of boilers, heat exchangers and pressure vessels made of cast steel and subjected to internal pressure, the safety factors shall not be less than:

$\eta_e = \eta_z = 2.2$; $\eta_m = 3.0$ and $\eta_p = 1.0$.

For components exposed to outer pressure, the safety factors η_e and η_m shall be increased by 20% (η_z remains unchanged).

2.5.4 Safety factors η_e and η_z for thermal loaded important parts of boilers shall be taken not less than:

3.0 – for corrugated furnaces;

2.5 – for plain furnaces, combustion chambers, stay combustion tubes, as well as long and short stays;

2.2 – for gas uptake pipes subjected to pressure and other similar gas heated walls.

2.5.5 Safety factors ηm for components made of cast iron shall be taken not less than 4.8 – for internal and external pressure.

This factor for non-ferrous metals – shall not be less than 4.6 for internal pressure and 5.5 for external pressure. For conical walls, in the latter case, η_m shall not be taken less than 6.0.

2.6 Strength Factors

2.6.1 Strength factors of welded joints ϕ shall be determined in accordance with Table 2.2 depending on the joint type and welding process.

For particular classes of boilers, pressure vessels and heat exchangers (see Table 1.1), strength factor ϕ shall not be less than that specified in Table 2.3.

Table 2.2

Welding process	Joint type	Weld type	ϕ
Automatic	Butt joints	Double-sided	1.0
		Single-sided with backing	0.9
		Single-sided without backing	0.8
	Overlap joint	Double-sided	0.8
		Single-sided	0.7
Semi-automatic and manual	Butt joints	Double-sided	0.9
		Single-sided with backing	0.8
		Single-sided without backing	0.7
	Overlap joint	Double-sided	0.7
		Single-sided	0.6

Notes:

1. Full penetration shall be achieved in each case.

2. For welded joints made in electro slag process, ϕ= 1 shall be taken.

Table 2.3

Kind of equipment	Factor ϕ		
	Class I	Class II	Class III
Boilers, steam superheaters and reservoirs	0.9	0.8	-
Steam-heated steam generators	0.9	0.8	-
Pressure vessels and heat exchangers	0.9	0.7	0.6

2.6.2 Strength factor of cylindrical walls weakened by holes with identical diameter shall be taken equal to the least of the following three values:

.1 strength factor of cylindrical walls weakened by a longitudinal row or a field of equally spaced holes (Figure2.1), as determined using the formula below:

$\phi = (a-d)/a$ (2.1)

.2 strength factor, reduced to the longitudinal direction, of cylindrical walls weakened by a transverse row or a field of equally spaced holes (Figure2.1), as determined using the formula below:

$\phi = 2(a_1-d)/a_1$ (2.2)

.3 strength factor, reduced to the longitudinal direction, of cylindrical walls weakened by a field of equally spaced staggered holes (Figure2.2 and Figure2.3), as determined using the formula below:

$\phi = k(a_2-d)/a_2$ (2.3)

where:

ϕ – strength factor of walls weakened by holes;

d – diameter of the hole for expanded tubes or inner diameter of welded-on tubes and extruded branch pieces, [mm];

a – spacing between axes of two adjacent holes arranged along the wall, [mm];

a_1 – spacing between axes of two adjacent holes in the transverse (circumferential) direction, taken as the mean circumference arc length, [mm];

a_2 – spacing between axes of two adjacent holes in staggered rows, taken as mean circumference arc length, [mm], as determined using the formula below:

$$a_2 = \sqrt{l^2 + l_1^2} \quad \text{[mm]}$$

l – spacing between axes of two adjacent holes in the longitudinal direction (see Figures 2.2 and 2.3), [mm];

l_1 – spacing between axes of two adjacent holes in the transverse or circumferential direction (see Figures 2.2 and 2.3), [mm];

k – factor depending on the ratio l_1/l taken from Table 2.4.

Table 2.4

l_1/l	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0	0.5
k	1.76	1.73	1.70	1.65	1.60	1.51	1.41	1.27	1.13	1.00

Note: Intermediate values of k shall be determined by linear interpolation.

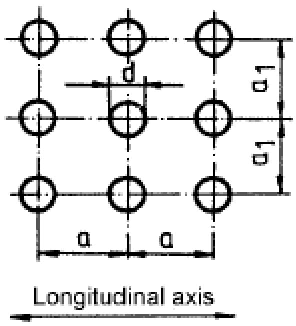


Figure 2.1

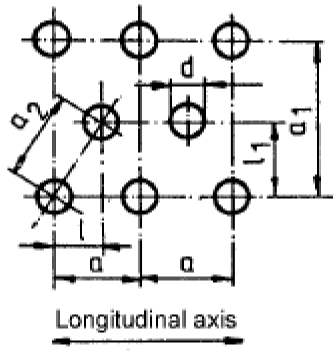


Figure 2.2

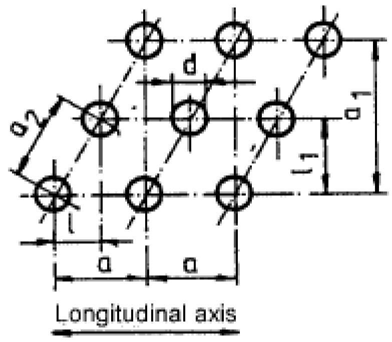


Figure 2.3

2.6.3 Where rows or fields of equally spaced holes contain holes of different diameters, value d in the formulae for strength factor determination (2.1 to 2.3) shall be taken as the value equal to the arithmetic mean of the two largest adjacent holes. In the case of uneven spacing between the holes of equal diameters, the lowest values of a, a_1 or a_2, respectively, shall be applied in the formulae for strength factor determination.

2.6.4 In the case of weld seams with holes, the strength factor shall be taken as the product of the seam strength factor and the strength factor of the wall weakened by the holes.

2.6.5 For seamless cylindrical walls not weakened by a seam or row/field of holes, strength factor ϕ shall be taken as equal to 1.0. In no case factor ϕ shall be taken greater than 1.0.

2.6.6 Strength factor of walls weakened by holes for expanded tubes, as determined in accordance with formulae 2.1 to 2.3, shall not be taken less than 0.3. Calculations with the lesser value of the strength factor are subject to ACS acceptance in each particular case.

2.6.7 For walls of cylindrical components made of sheets with different thickness, joined by longitudinal weld seam, the thickness calculation shall be done separately for each sheet, taking account of the actual weakenings.

2.6.8 For tubes with longitudinal weld seam, the strength factor is subject to ACS acceptance in each particular case.

2.6.9 Strength factors for walls weakened by openings requiring full or partial strengthening shall be determined in acordance with 2.19.

2.6.10 Strength factors for flat flue sheets shall be determined in accordance with formula 2.1 for tangential and radial spacings respectively. The lesser obtained strength factor shall be taken for calculation of the flat flue sheet thickness.

2.7 Design Thickness Allowances

2.7.1 In every case where the design wall thickness allowance c, is not expressly specified, it shall be taken at least 1 mm. For steel walls with more than 30 mm in thickness, as well as for walls of corrosion-resistant non-ferrous metals or high alloy materials, and for materials adequately protected against corrosion, e.g. by cladding or coating with a protective compound, the design thickness allowance may be waived subject to ACS acceptance in each particular case.

2.7.2 For pressure vessels and heat exchangers inaccessible for internal examination and for those whose are subjected to heavy corrosion or wear, ACS may require an increased allowance c to the design thickness.

2.8 Cylindrical and Spherical Elements and Tubes Subjected to Internal Pressure

2.8.1 The requirements specified in this sub-chapter apply where the following conditions are fulfilled:

$D_a/D \leq 1.6$ – for cylindrical elements;

$D_a/D \leq 1.7$ – for tubes;

$D_a/D \leq 1.2$ – for spherical elements.

Cylindrical elements with a diameter $D_a \leq 200$ mm shall be considered as tubes.

For D_a , D – see paragraph 2.8.2.

2.8.2 Thickness of cylindrical walls and tubes shall not be less than that calculated in accordance with the formulae below:

$$s = \frac{D_a p}{2\sigma\varphi + p} + c \quad \text{[mm]} \qquad \text{or} \qquad s = \frac{Dp}{2\sigma\varphi - p} + c \ \text{[mm]} \qquad (2.4)$$

s – wall thickness, [mm];

p – design pressure, [MPa];

D_a – outside diameter, [mm];

D – inside diameter, [mm];

ϕ – strength efficiency factor (see 2.6);

σ – allowable stress (see 2.4.5), [MPa];

c – design thickness allowance (see 2.7), [mm].

2.8.3 Spherical wall thickness shall not be less than those obtained from the formula:

$$s = \frac{D_a p}{4\sigma\varphi + p} + c \quad \text{[mm]} \qquad \text{or} \qquad s = \frac{Dp}{4\sigma\varphi - p} + c \ \text{[mm]} \qquad (2.5)$$

For symbols – see paragraph 2.8.2.

2.8.4 Irrespective of the values obtained in accordance with formulae 2.4 and 2.5, the thickness of spherical and cylindrical walls and tubes shall not be less than:

.1 5 mm – for seamless and welded elements;

.2 12 mm – for tube plates with radial hole arrangement for expanded tubes;

.3 6 mm – for tube plates with welded-on and soldered-on tubes;

.4 specified in Table 2.5 – for tubes.

Thickness of tube walls heated by gas with temperature exceeding 800°C shall not be less than 6 mm.

Table 2.5

Tube outside diameter, [mm]	≤20	>20 ≤30	>30 ≤38	>38 ≤51	>51 ≤70	>70 ≤95	>95 ≤102	>102 ≤121	>121 ≤152	>152 ≤191	>191
Minimum wall thickness, [mm]	1.75	2.0	2.2	2.4	2.6	3.0	3.25	3.5	4.0	5.0	5.4

Note: The decrease in wall thickness due to expanding or bending shall be compensated by allowances.

2.8.5 The minimum wall thickness of pipes made of non-ferrous alloys and stainless steel may be less than those specified in paragraph 2.8.4, however not less than those determined in accordance with formulae 2.4 and 2.5.

2.9 Elements Subjected to External Pressure

2.9.1 The requirements specified in this sub-chapter apply to cylindrical walls with:

$D_a/D \leq 1.2$

Wall thickness of pipes with $D_a \leq 200$ mm in diameter shall be determined in accordance with paragraph 2.8.2.

2.9.2 Plain wall thickness of cylindrical elements, with or without stiffeners including plain furnaces of boilers shall not be less than that determined in accordance with the formula below:

$$s = \frac{50(B + \sqrt{B^2 + 0.04AC})}{A} + c, \qquad \text{[mm] (2.6)}$$

where:

$$A = 200\frac{\sigma}{D_m}\left(\frac{1 + D_m}{10\,l}\right)\left(1 + \frac{5D_m}{l}\right), \quad B = p\left(1 + \frac{5D_m}{l}\right), \quad C = 0.045pD_m$$

s – wall thickness, [mm];

p – design pressure (see 2.2), [MPa];

D_m – mean diameter, [mm];

σ– allowable stress (see 2.4.5), [MPa];

c – design thickness allowance (see 2.7), [mm];

l – design length of cylindrical portion between stiffeners, [mm].

End plates and stiffening rings, furnace connections to end plates and combustion chamber as well as stiffening (Figure 2.4) or similar structures may be considered as stiffeners.

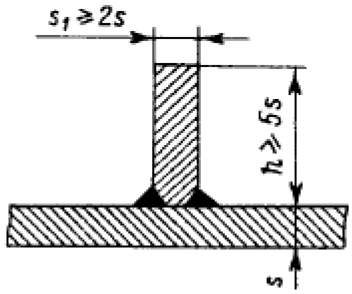


Figure 2.4

2.9.3 Corrugated furnaces shall have a thickness not less than that determined in accordance with the formula below:

$$s = \frac{Dp}{2\sigma} + c \qquad (2.7)$$

s – wall thickness, [mm];

D – minimum inner diameter of the corrugated portion of furnace, [mm];

p – design pressure (see 2.2), [MPa];

σ– allowable stress (see 2.4.5), [MPa];

c – design thickness allowance (see 2.7), [mm].

2.9.4 Where the length of the straight portion of a corrugated furnace from the front-end wall to the commencement of the first corrugation exceeds the corrugation length, the wall thickness over this portion shall not be less than that calculated in accordance with formula 2.6.

2.9.5 Thickness of plain furnaces shall not be less than 7 mm however not more than 20 mm. The thickness of corrugated furnaces shall not be less than 10 mm however not more than 20 mm.

2.9.6 Plain furnaces up to 1400 mm in length need not be fitted with stiffening rings. Where a boiler has two or more furnaces, the stiffening rings of adjacent furnaces shall be arranged in alternate planes.

2.9.7 Holes and openings in cylindrical and spherical walls shall be compensated for in accordance with the requirements specified in 2.19.

2.9.8 Thickness s_1 of the vertically loaded ring formed by connection of combustion chamber with vertical boiler shell (see Figure 2.5), shall not be less than that determined in accordance with the formula below:

$$s_1 = \frac{3.7}{\sigma}\sqrt{pD_1(D_1 - D_0)} + 1 \text{ [mm]} \qquad (2.8)$$

p – design pressure, [MPa].

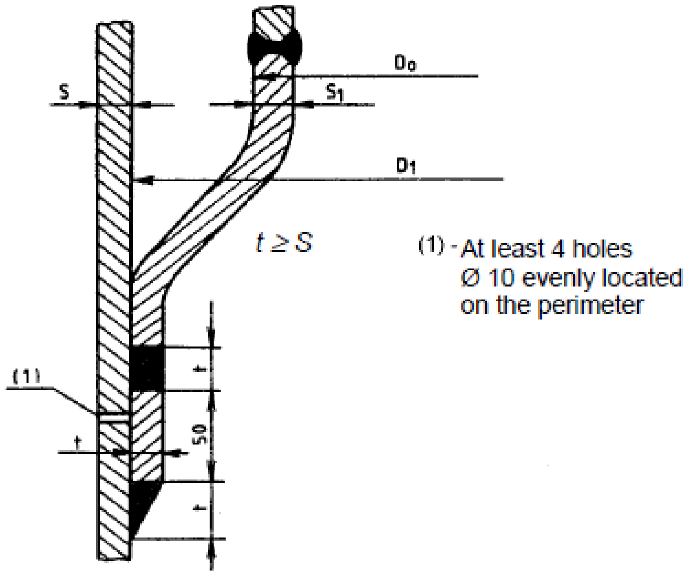


Figure 2.5

2.10 Conical Elements

2.10.1 Wall thickness of conical elements subjected to internal pressure shall not be less than:

.1 at $\alpha \leq 70^o$– the greater value out of those determined in accordance with the formulae below:

$$s = \frac{D_a p y}{4\sigma\varphi} + c, \text{ [mm] and } s = \frac{D_a p y}{(4\sigma\varphi - p)\cos\alpha} + c \text{ [mm]} \qquad (2.9)$$

.2 at $\alpha > 70^o$– the value determined in accordance with the formula below:

$$s = 0.3\,[D_a - (r+s)]\sqrt{\frac{p}{\sigma\varphi}\frac{\alpha}{90^o}} + c \text{ [mm]} \qquad (2.10)$$

s – wall thickness, [mm];

D_c – design diameter (Figures 2.6-1 to 2.6-4), [mm];

Da – outside diameter (Figures 2.6-1 to 2.6-4), [mm];

p – design pressure (see 2.2), [MPa];

y – shape factor (see Table 2.6);

α, α_1 , α_2 , α_3 – angles (Figures 2.6-1 to 2.6-4), [^{o}];

σ– allowable stress (see 2.4.5), [MPa];

ϕ– strength factor (see sub-chapter 2.6). In formulae 2.9 and 2.10.1.2 the strength factor for circumferential weld seam shall be applied, whereas in formula 2.10 – for longitudinal weld seam.

For seamless conical shell segments, and also where circumferential seam is at the distance from the edge exceeding:

$$0.5\sqrt{\frac{D_a s}{\cos\alpha}}$$

strength factor ϕ= 1 shall be taken;

r – edge radius (Figures 2.6-1, 2.6-2 and 2.6-4), [mm];

c – design thickness allowance (see 2.7), [mm];

Table 2.6

α,	Shape factor *y* as function of *r* / D_a ratio											
[degs]	0.01	0.02	0.03	0.04	0.06	0.08	0.10	0.15	0.20	0.30	0.40	0.50
1	2	3	4	5	6	7	8	9	10	11	12	13
10	1.4	1.3	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
20	2.0	1.8	1.7	1.6	1.4	1.3	1.2	1.1	1.1	1.1	1.1	1.1
30	2.7	2.4	2.2	2.0	1.8	1.7	1.6	1.4	1.3	1.1	1.1	1.1
45	4.1	3.7	3.3	3.0	2.6	2.4	2.2	1.9	1.8	1.4	1.1	1.1
60	6.4	5.7	5.1	4.7	4.0	3.5	3.2	2.8	2.5	2.0	1.4	1.1
75	13.6	11.7	10.7	9.5	7.7	7.0	6.3	5.4	4.8	3.1	2.0	1.1

Note:

For welded joints (see Figure 2.6-3), shape factor y shall be determined for r / Da = 0.01.

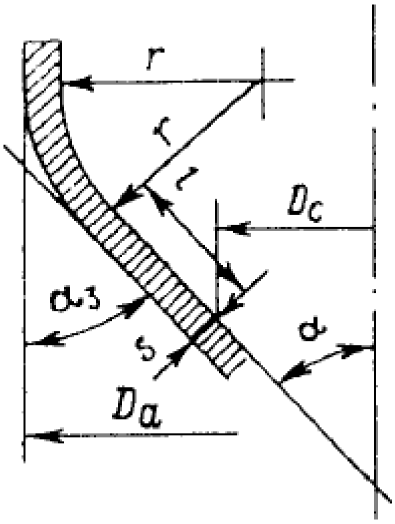


Figure 2.6-1

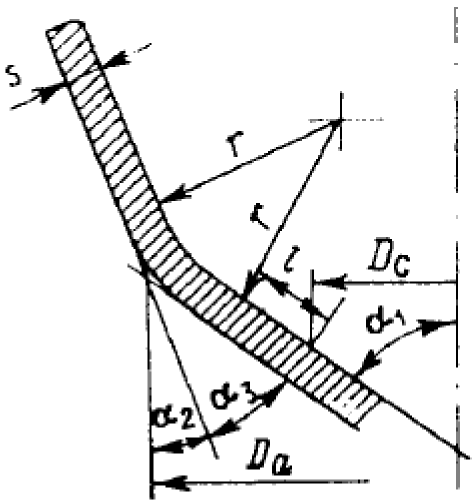


Figure 2.6-2

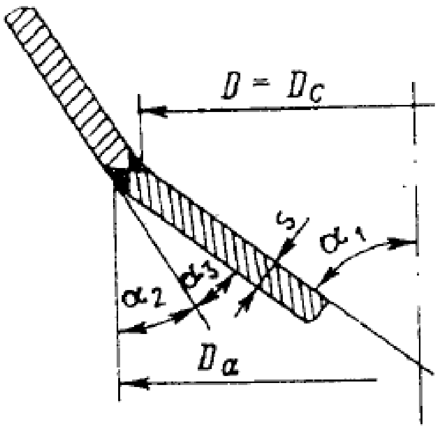


Figure 2.6-3

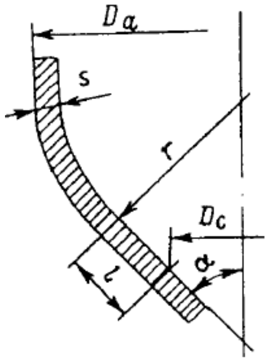


Figure 2.6-4

l – distance from the edge of the wide end of conical shell, along the generatrix, taken as tenfold wall thickness, however not greater than half the length of the conical shell generatrix segment (Figures 2.6-1, 2.6-2 and 2.6-4), [mm].

2.10.2 The wall thickness of conical elements subjected to external pressure shall be determined in accordance with paragraph 2.10.1, provided the following conditions are fulfilled:

.1 strength factor of welded joint ϕ= 1 shall be taken;

.2 allowance c shall be taken equal to 2 mm;

.3 design diameter D_c shall be determined in accordance with the formula below:

$$D_c = \frac{d_1 + d_2}{2\cos\alpha} \quad \text{[mm] (2.11)}$$

d_1 , d_2 – the largest and the smallest diameter of the cone, respectively, [mm];

.4 for $\alpha < 45^{o}$ it shall be demonstrated that the walls are not subject to plastic strain. Pressure p_1, at which plastic strain occurs, shall be determined in accordance with the formula below:

$$p_1 = 26E10^{-6}\frac{D_c}{l_1}\left[\frac{100(s-c)}{D_c}\right]^2\sqrt{\frac{100(s-c)}{D_c}} \quad \text{[MPa]} \qquad (2.12)$$

E – modulus of elasticity, [MPa];

l_1 – the maximum length of the cone or distance between its supports, [mm].

Fulfilment of inequality $p_1 > p$ (p – design pressure, [MPa]) is the condition of absence of plastic strain of the cone walls.

2.10.3 Welded joints (see Figure 2.6-3) are permitted only with the values of angle α3≤ 30oand wall thickness s ≤ 20 mm. The joints shall be double-side welded. In conical shell segments with α ≥ 70o, welded joints may be made without edge bevelling provided that the requirements specified in paragraph 2.10.2 are fulfilled. Such joints are not recommended in boilers.

2.10.4 In way of holes and openings in conical walls, adequate strengthening shall be provided in accordance with the requirements specified in 2.19.

2.11 Flat End Plates and Covers

2.11.1 The thickness of the flat end plates unsupported by stays, as well as of welded or bolted covers (Figures 2.7-1 to 2.7-8) shall not be less than that determined in accordance with the formula below:

$$s = KD_c\sqrt{\frac{p}{\sigma}} + c \quad \text{[mm]} \qquad (2.13)$$

s – wall thickness, [mm];

K – design factor for the design patterns shown in Figures 2.7-1 to 2.7-8, [mm];

D_c – design diameter (Figures 2.7-2 to 2.7-7), [mm]. For such end plates as shown in Figure 2.7-1, the design diameter shall be:

D_c = D-r [mm] (2.7-2)

For rectangular or oval covers, the design diameter shall be determined in accordance with the formula below:

$$D_c = m\sqrt{\frac{2}{1+(m/n)^2}} \quad \text{[mm]} \qquad (2.14)$$

D_b – pitch circle diameter of bolts (Figure 2.7-6), [mm];

D – inner diameter, [mm];

n and m – the maximum and minimum length of the axis or the side of the opening respectively, measured to the axis of the packing arrangement (Figure 2.7-8), [mm];

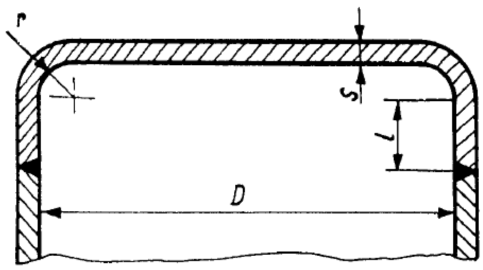
r – inner curvature radius of the dished end plate, [mm];

p – design pressure (see 2.2), [MPa];

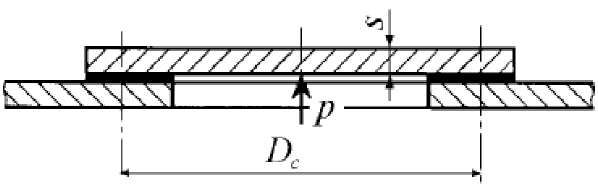
σ– allowable stress (see 2.4.5), [MPa];

c – design thickness allowance (see 2.7), [mm];

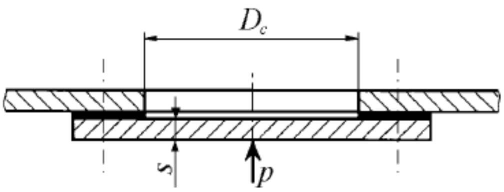
l – length of cylindrical portion of end plate (Figure 2.7-1), [mm].



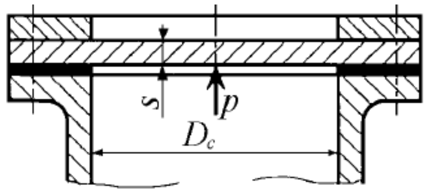
K = 0.30 Figure 2.7-1



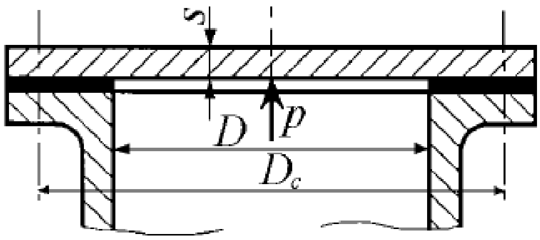
K = 0.41 Figure 2.7-2



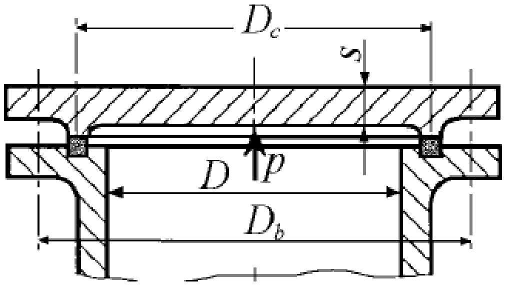
K = 0.41 Figure 2.7-3



K = 0.45 Figure 2.7-4

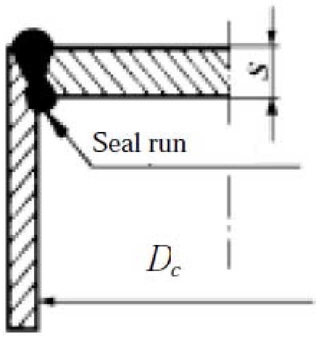


K = 0.35 Rys. 2.7-5



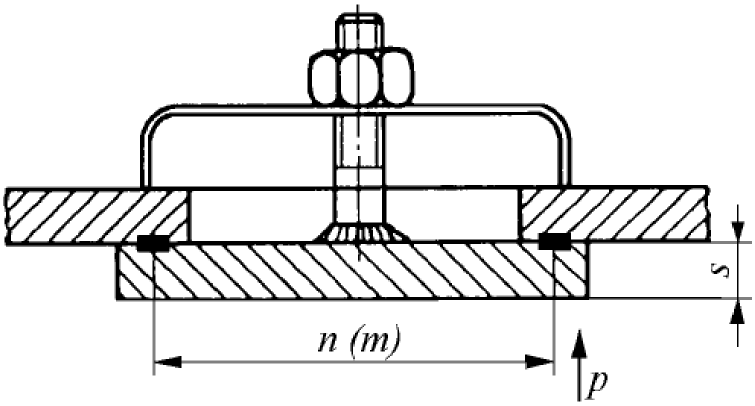
Db/D	1.25	1.50	1.75
K	0.6	0.7	0.8

Figure 2.7-6



K = 0.50

Figure 2.7-7



K = 0.53 Figure 2.7-8

2.11.2 The following conditions shall be fulfilled:

.1 For circular end plates

$$0.771 s_1 \geq s_2 \geq \frac{1.3p}{\sigma}(D_c/2 - r) \qquad (2.15)$$

.2 For rectangular end plates

$$0.55 s_1 \geq s_2 \geq \frac{1.3p}{\sigma}\frac{nm}{(n+m)} \qquad (2.16)$$

s – end plate thickness, [mm];

s_1 – shell thickness, [mm];

s_2 – end plate thickness within the relieving groove, [mm].

For explanation of other symbols – see 2.11.

Thickness s_2 shall never be less than 5 mm.

The above conditions are applicable to end plates of not more than 200 mm in diameter or side length. The dimensions of relieving grooves in end plates with diameters or side lengths over 200 mm are subject to ACS acceptance in each particular case.

2.12 Flat Walls Strengthened by Stays

2.12.1 Flat walls (Figures 2.8-2 and 2.8-3) strengthened by long and short stays, corner stays, stay tubes or other similar structures shall have a thickness not less than that determined in accordance with the formula below:

$$s = KD_c\sqrt{\frac{p}{\sigma}} + c \qquad (2.17)$$

K – design factor (see Figures 2.8-1 to 2.8-3); if the part of the wall area in question is reinforced by stays having variable values of K factor, the formula shall be used with K value equal to the arithmetic mean of these factors.

D_c – calculation diameter (Figs. 2.8-2 and 2.8-3), [mm];

With even arrangement of stays:

$$D_c = \sqrt{a_1^2 + a_2^2} \qquad (2.18)$$

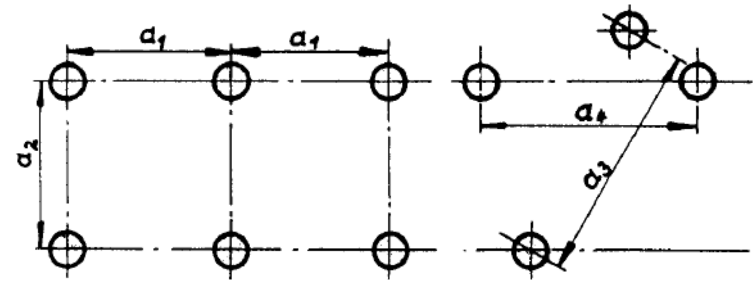
with uneven arrangement of stays:

$$D_c = (a_3 + a_4)/2 \qquad (2.19)$$

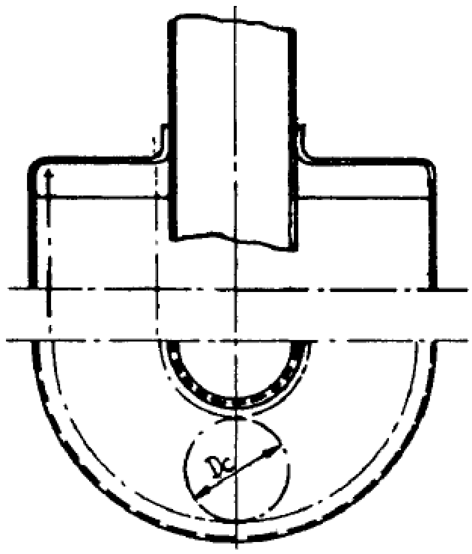
In all other instances, the values of D_c shall be taken as equal to the diameter of the largest circle which can be drawn through the centres of three stays or through the centres of stays and the commencement of the wall flanging curvature if the radius of the latter satisfies the requirements specified in 2.13; in this case, the flanging shall be regarded as a point of support. A manhole flanging shall not be regarded as a point of support;

a_1 , a_2 , a_3 , a_4 – pitch or stay-to-stay distance (Figure 2.8-1), [mm].

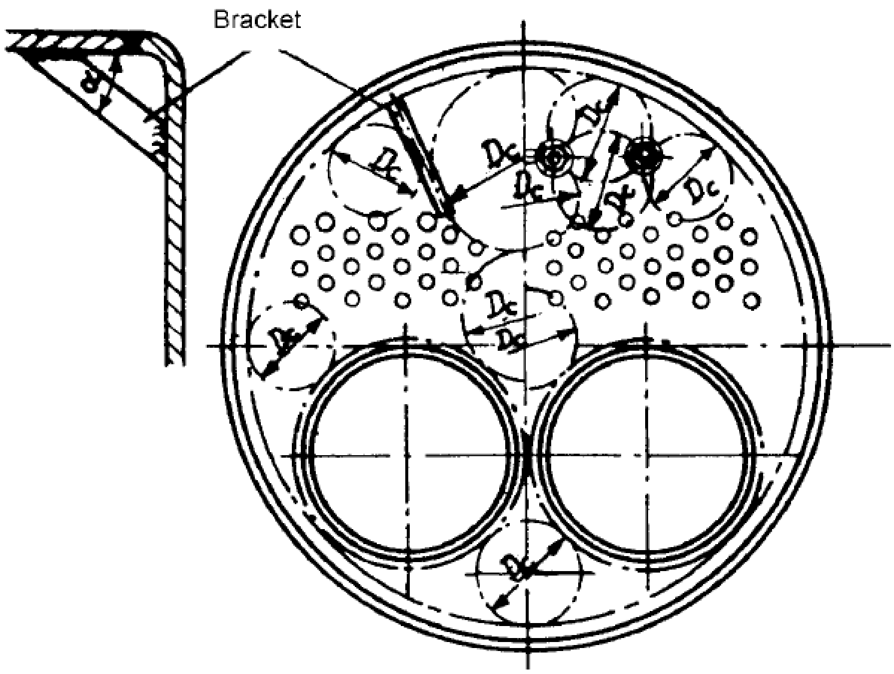
For other symbols – see 2.11.



K = 0.45, Figure 2.8-1



K= 0.50, Figure 2.8-2



K= 0.35 (for the bracket) Figure 2.8-3

2.13 Flanging Flat Walls

2.13.1 In flat wall and end plate calculations, the flanging can be taken into account when the inner flanging radius is not less than that specified in Table 2.7.

Table 2.7

End plate outer diameter [mm]	Flanging radius [mm]
up to 350	25
from 350 to 500	30
from 500 to 950	35
from 950 to 1400	40
from 1400 to 1900	45
over 1900	50

The inner flanging radius shall not be less than 1.3 times the wall thickness.

2.13.2 The length of cylindrical portion of a flanged flat end plate shall not be less than determined in accordance with the following formula: $I = 0.5\sqrt{Ds}$, (see Figure 2.7-1).

2.14 Strengthening of Openings in Flat Walls

2.14.1 In flat walls, end plates and covers, openings with diameters greater than four times the thickness shall be strengthened by means of welded-on branch pieces or pads, or by increasing the design wall thickness. The openings shall be arranged at a distance not less than 0.125 times the design diameter from the design diameter outline.

2.14.2 If the actual wall thickness is greater than that determined in accordance with formulae 2.13 and 2.17, the maximum diameter of a not strengthened opening shall be determined in accordance with the formula below:

$$d = 8s_r\left(1.5s_r^2/s^2 - 1\right) \qquad (2.20)$$

d – diameter of not strengthened opening, [mm];

s_r – actual wall thickness, [mm];

s – determined in accordance with formulae 2.13 and 2.17, [mm].

2.14.3 Edge reinforcement shall be provided for openings of larger diameters than those specified in paragraphs 2.14.1 and 2.14.2.

The dimensions of reinforcing elements of branches shall fulfil the following condition:

$$s_k\left(h^2/s_r^2 - 0.65\right) \geq 0.65d - 1.4s_r \qquad (2.21)$$

s_k – branch piece wall thickness, [mm], (see Figure 2.9), [mm];

d – branch piece inside diameter, [mm];

s_r – see paragraph 2.14.2, [mm];

$h = h_1 + h_2$, [mm], (see Figure 2.9).

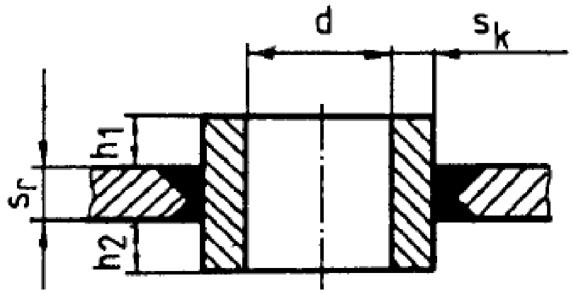


Figure 2.9

2.15 Tube Plates

2.15.1 Thickness s_1 of flat tube plates of heat exchangers shall not be less than that determined in accordance with the formula below:

$$s_1 = 0.9KD_w\sqrt{\frac{P}{\sigma\varphi}} + c \text{ [mm]} \qquad (2.22)$$

K – factor depending on the ratio of shell wall thickness s to tube plate thickness s_1; for tube plates welded to the shell, K shall be determined in accordance with diagram 2.10 on the preliminary assumption of s_1 thickness, and the calculation shall be corrected if the difference between assumed value of s_1 and that determined in accordance with formula 2.22 exceeds 5%;

for the tube plate fastened by bolts or stud-bolts between the body and cover flanges K = 0.5;

D_W – shell inner diameter, [mm];

P – design pressure (see 2.2), [MPa];

σ– allowable stress (see 2.4.5), [MPa];

for heat exchangers of rigid structure where the thermal elongation factors of shell and pipe materials are different, σ shall be reduced by 10%;

ϕ– strength factor of tube plate weakened by holes for pipes (see 2.15.2);

c – design thickness allowance (see 2.7), [mm].

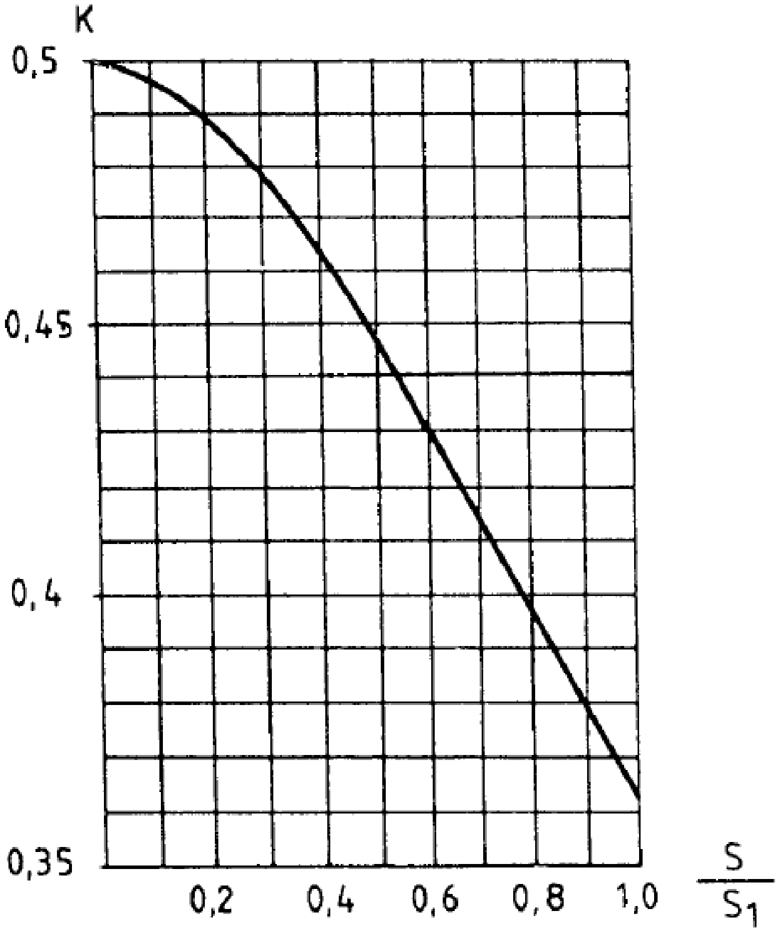


Figure 2.10

2.15.2 Where 0.75 > d / a > 0.4 and DW / s_1 ≥ 40, the strength factor of a tube plate shall be calculated in accordance with the following formulae:

where holes are arranged in an equilateral triangle pattern:

$$\varphi = 0.935 - 0.65 d / a \qquad (2.23)$$

where holes are arranged in a row or in transposition:

$$\varphi = 0.975 - 0.68 d / a_2 \qquad (2.24)$$

d – diameter of tube plate holes, [mm];

a – spacing of hole-axes arranged in triangle pattern, [mm];

a_2 – spacing of hole-axes arranged in row or in transposition (as well as arranged concentrically), whichever is lesser, [mm].

2.15.3 For quotients d / a = 0.75 + 0.80, the tube plate thickness determined in accordance with formula 2.22 shall fulfill the condition below:

$f_{min} \geq 5d$

f_{min} – minimum allowable cross sectional area of bridge in tube plate, [mm^2].

For values of d/a and D_w/S_1 other than those specified above, as well as for heat exchangers with rigid structure when the difference in mean temperatures exceeds 50 ^oC, the thickness of tube plates is subject to ACS acceptance in each particular case.

2.15.4 In addition to the requirement specified in paragraph 2.14.1, the thickness of tube plates with expanded tubes shall fulfill the condition below:

$$s \geq 10 + 0.125\ d \qquad (2.25)$$

Expanded connections of tubes to tube plates shall also fulfil the requirements specified in paragraphs 2.20.6, 2.20.7 and 2.20.8.

2.15.5 If tube plates are stregthened by welded or expanded pipes in accordance with the requirements specified in sub-chapter 2.20, then the calculations of such tubes may be performed in accordance with the requirements specified in 2.12.

2.16 Dished Ends

2.16.1 Thickness of dished ends, whether unpierced or pierced, subjected to internal or external pressure (see Figure 2.11) shall not be less than that determined in accordance with the formula below:

$$s = D_a P y / 4\sigma\varphi + c \qquad (2.26)$$

s – end wall thickness, [mm];

p – design pressure, [MPa];

D_a – end outer diameter, [mm].

The end shall be flanged within the distance not less than 0.1 D_a measured from the outer edge of the end cylindrical portion (see Figure 2.11);

ϕ– strength factor (see 2.6);

σ– allowable stress (see 2.4.5), [MPa];

y – shape factor determined in accordance with Table 2.6 depending on the ratio of the height to outside diameter of the end and on the value of weakening by holes; for intermediate values of h_a /D and $d/\sqrt{D_a s}$, shape factor y may be determined by linear interpolation.

To determine y in accordance with Table 2.8, the preliminary value s shall be preliminary taken from the standardized thickness series. The final value of s shall not be less than that determined in accordance with formula 2.26.

For elliptical and basket shaped ends, R_W is the maximum radius of curvature.

Table 2.8

End Shape	Ratio h_a / D_a	Shape Factor							
		y- for flanged area and unpierced ends	y_A – for dished part of end with not strengthened holes with respect to						y_C – for dished part of end with strengthened holes
			0.5	1.0	2.0	3.0	4.0	5.0	
Dished elliptical or basket shaped ends with $R_W = D_a$	0.20	2.9	2.9	2.9	3.7	4.6	5.5	6.5	2.4
Dished elliptical or basket shaped ends with $R_W = 0.8\ D_a$	0.25	2.0	2.0	2.3	3.2	4.1	5.0	5.9	1.8
Dished elliptical or basket shaped ends with $R_W = 0.5\ D_a$	0.50	1.1	1.2	1.6	2.2	3.0	3.7	4.35	1.1

c – design thickness allowance, to be taken equal to:

2 mm – if subjected to internal pressure;

3 mm – if subjected to external pressure;

for wall thickness exceeding 30 mm, the above values of allowance may be reduced by 1 mm.

d – the largest diameter of not strengthened hole, [mm].

Formula 2.26 is applicable if the following conditions are fulfilled:

$$h_a / D_a \geq 0.18;\ (s-c)/D_a \geq 0.0025;\ R_w \leq D_a;\ \ r \geq 0.1 D_a;\ l \leq 150 \qquad ,\text{[mm]}$$

where:

$l \geq 25$ mm for $s \leq 10$ mm,

$l \geq 15 + s$, [mm] for $10 < s \leq 20$ mm,

$l \geq 25 + 0.5\ s$, [mm] for $s > 20$ mm.

The symbols for dimensions of dished end elements are shown in Figure 2.11.

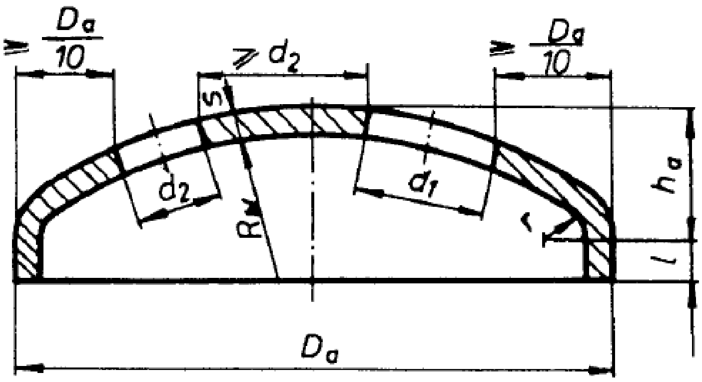


Figure 2.11

2.16.2 Unpierced ends as well as ends with holes whose diameter is not greater than 4s and not greater than 100 mm arranged at a distance not less than 0.2Da from the outer cylindrical portion of the end are also considered as unpierced ends.

Not strengthened holes with the diameter less than the wall thickness, however not exceeding 25 mm, are permitted in way of the end curvature.

2.16.3 Wall thickness of dished ends in combustion chambers of vertical boilers may also be calculated as for unpierced ends where the flue gas outlet branch passes through the end.

2.16.4 Dished ends subjected to external pressure, except for those of cast iron, shall be checked for shape stability using the following formula:

$$\frac{36.6E_T}{R_w^2}\frac{(s-c)^2}{100p} > 3.3 \qquad (2.27)$$

E_T – modulus of elasticity at design temperature, [MPa];

for modulus of elasticity for steel – see Table 2.9, for non-ferrous materials the modulus of elasticity value is subject to ACS acceptance in each particular case;

R_W – maximum inner radius of curvature, [mm].

For other symbols – see paragraph 2.16.1.

Table 2.9

Design temperature T, [°C]	20	250	300	400	500
Modulus of elasticity E_T for steel,[MPa]	206000	186000	181000	172000	162000

2.16.5 The minimum wall thickness of dished steel ends shall be not less than 5 mm. For ends made of non-ferrous alloys, the minimum wall thickness may be reduced subject to ACS acceptance in each particular case.

2.16.6 Application of dished ends of welded construction is subject to ACS acceptance in each particular case.

2.17 Flanged End Plates

Thickness of unpierced flanged end plates (see Figure 2.12) subjected to internal pressure shall not be less than that determined in accordance with the formula below:

$$s = 3Dp/\sigma + c \qquad (2.28)$$

s – wall thickness, [mm];

p – design pressure (see 2.2), [MPa];

D – inside diameter of end plate, taken equal to shell internal diameter, [mm];

σ– allowable stress (see 2.4.5), [MPa];

c – design thickness allowance (see 2.7), [mm].

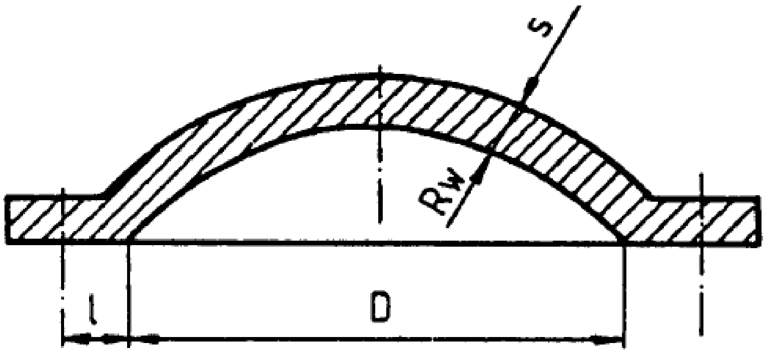


Figure 2.12

Flanged end plates are allowed within a range of diameters D up to 500 mm and for working pressures not higher than 1.5 MPa. The end plate curvature radius R_W shall not be less than 1.2 D, and the distance l shall not exceed 2s.

2.18 Headers of Rectangular Section

2.18.1 The wall thickness of rectangular headers (Figure 2.13-1) subjected to the internal pressure shall not be less than that determined in accordance with the formula below:

$$s = \frac{pn}{2.52\sigma\varphi_1} / + \sqrt{\frac{4.5Kp}{1.26\sigma\varphi_2}} \qquad (2.29)$$

s – wall thickness, [mm],

p – design pressure (see 2.2), [MPa],

n – half of the width of the header side normal to that being calculated, [mm],

m – half of the width of the header side being calculated, [mm],

σ – allowable stress (see 2.4.5), [MPa],

ϕ_1 and ϕ_2 – strength factors of headers, weakened by holes, determined as follows:

ϕ_1 – in accordance with formula 2.1,

ϕ_2 – in accordance with formula 2.1, if d < 0.6m,

$\varphi_2 = 1 - 0.6m/\alpha$, if d ≥ 0.6 m (2.30)

d – diameter of holes, [mm]. For oval holes, d shall be taken as equal to the size of holes at the longitudinal axis, however in formulae 2.1 and 2.30 the size at the axis perpendicular to the header centre line shall be taken as d for oval holes.

Where the holes are arranged in staggered pattern, a_2 (see Figure 2.13-2) shall be substituted for a in formula 2.30. Where the rectangular headers have longitudinal welds (see Figure 2.13-1), strength factors, ϕ_1 and ϕ_2 shall be taken as equal, respectively, to the joint factors of weld seams selected as required in 2.6.

Longitudinal welded joints shall be arranged, as far as possible, within the area l_1, for which K = 0. Where the header wall is weakened in several different locations, the lowest value of strength factor shall be taken for calculations.

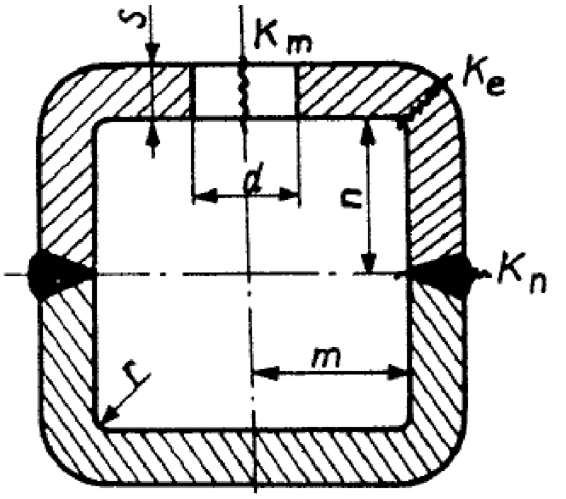


Figure 2.13-1

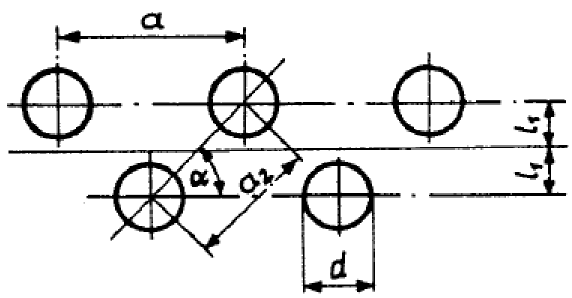


Figure 2.13-2

K – design factor for bending moment at the centre of side wall or at the centre line of the row of holes, calculated from the formula:

for the centre line of the header wall

$$K_m = \frac{m^3 + n^3}{3(m+n)} - \frac{m^2}{2} \quad [\text{mm}^2] \qquad (2.31)$$

for rows of holes or longitudinal welds

$$K_n = \frac{m^3 + n^3}{3(m+n)} - \frac{m^2 - l_1^2}{2} \quad [\text{mm}^2] \qquad (2.32)$$

If the above formulae give negative results, then their absolute values shall be used; where the holes are arranged in a staggered pattern, factor K shall be multiplied by cos α;

α– angle between diagonal pitch line of holes and header axis, [°];

l_1 – distance between the row of holes under consideration and the centre line of header wall (Figure 2.13-2), [mm].

2.18.2 If fillet welds are accepted by ACS in headers, then the wall thickness of such headers shall not be less than that determined in accordance with the formula below:

$$s = \frac{p\sqrt{m^2 + n^2}}{2.52\sigma\varphi_1} + \sqrt{\frac{4.5K_e p}{1.26\sigma\varphi_2}} \qquad (2.33)$$

Ke – design factor for bending moment at the edges, [mm²], determined in accordance with the formula below:

$$K_e = \frac{m^3 + n^3}{3(m+n)} \qquad (2.34)$$

For other symbols used – see 2.18.1.

2.18.3 Fillet radius of rectangular header side edges shall not be less than 0.33 times the wall thickness, however not less than 8 mm. The minimum thickness of header wall with expanded tubes shall not be less than 14 mm. The width of bridges between the holes shall not be less than 0.25 times the spacing of the hole centres. The wall thickness in way of the fillets shall not be less than that determined in accordance with formulae 2.29 and 2.33.

2.19 Openings in Cylindrical, Spherical, Conical Walls and in Dished Ends

2.19.1 Strengthening arrangements shall be provided in way of openings.

The following strengthening methods are permitted:

.1 wall thickness increased above the design thickness (Figs. 2.14-1 and 2.14-2);

.2 disk-shaped strengthening plates welded on the wall being strengthened (Figs. 2.14-3 and 2.14-4);

.3 welded-on pipe elements, such as branch pieces, sleeves etc. (Figures 2.14-5 to 2.14-7).

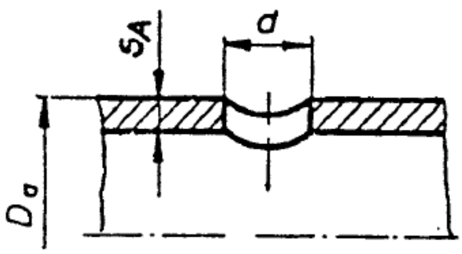


Figure 2.14-1

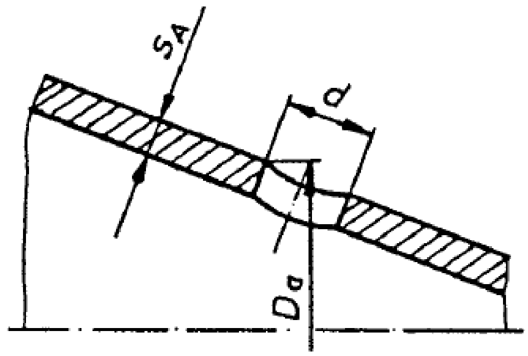


Figure 2.14-2

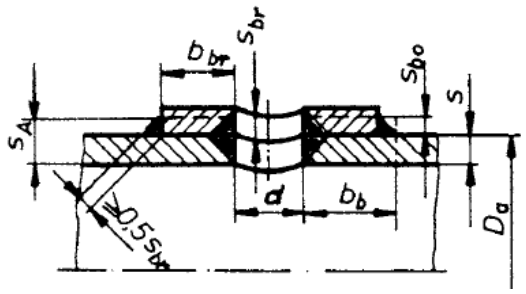


Figure 2.14-3

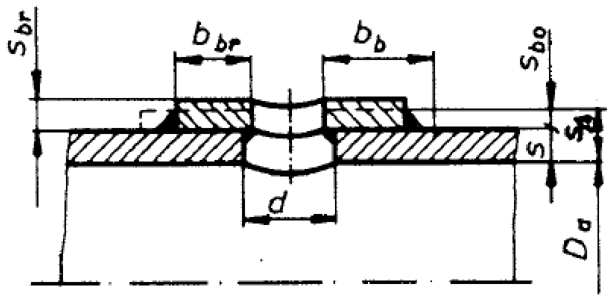


Figure 2.14-4

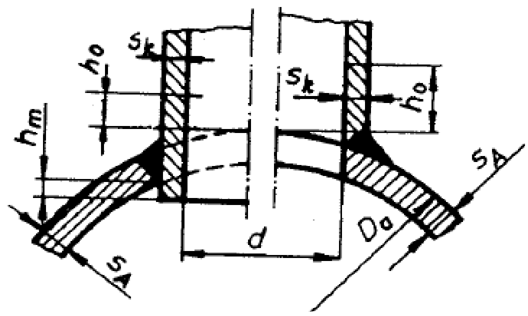


Figure 2.14-5

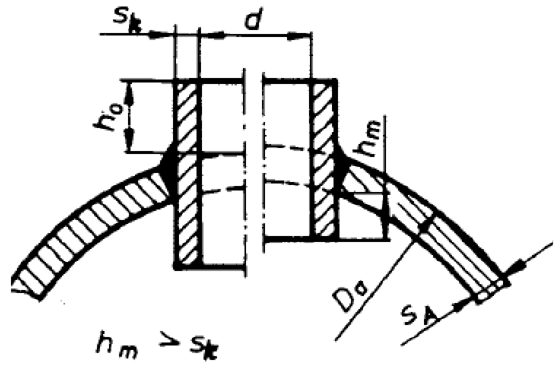


Figure 2.14-6

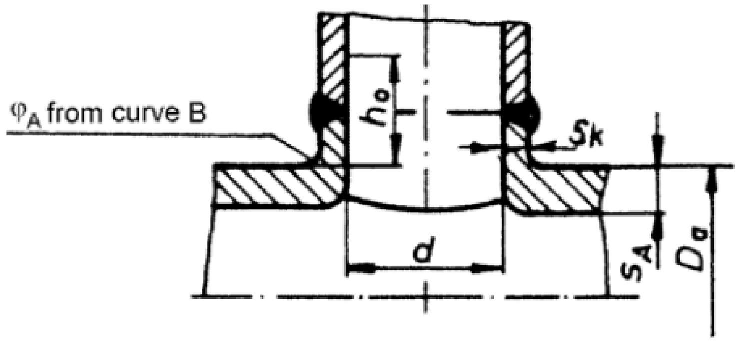


Figure 2.14-7

It is recommended that opening strengthening elements, as shown in Figures 2.14-5 to 2.14-7, be welded with temporary backing or using other techniques ensuring proper penetration of the welded joint.

2.19.2 Thickness of pierced walls shall fulfill the requirements specified in 2.8 and 2.9 for cylindrical walls, in 2.10 – for conical walls and in 2.16 – for dished ends.

2.19.3 Materials used for the walls being strengthened and for strengthening elements shall have identical strength characteristics, if possible. Where the materials of strengthening elements have worse strength characteristics than the wall material, the cross-sectional area strengthening elements shall be increased accordingly.

Strengthening elements shall be properly connected to the wall being strengthened.

2.19.4 Openings in walls shall be located at a distance equal at least triple wall thickness, however not less than 50 mm from the welded joints. The arrangement of openings at the distance less than 50 mm from the welded joints is subject to ACS acceptance in each particular case.

2.19.5 Opening diameter (or the largest dimension of an opening other than circular) shall not exceed 500 mm. Application of openings greater than 500 mm and their strengthening methods are subject to ACS acceptance in each particular case.

2.19.6 In general, wall thickness of tubular elements (branch pieces, sleeves or nozzles) welded to the walls of pressure vessels and heat exchangers shall not be less than 5 mm. Application of elements less than 5 mm in thickness is subject to ACS acceptance in each particular case.

2.19.7 Opening may be strengthened by increasing design thickness of the wall. In that case, increased wall thickness s_A shall not be less than the value determined in accordance with the following formulae:

for cylindrical shells

$$s_A = \frac{pD_a}{2\sigma\varphi_A + p} + c \qquad (2.35)$$

for spherical shells

$$s_A = \frac{pD_a}{4\sigma\varphi_A + p} + c \qquad (2.36)$$

for conical shells

$$s_A = \frac{pD_a}{(2\sigma\varphi_A - p)\cos\alpha} + c \qquad (2.37)$$

s_A – required wall thickness without compensating elements, [mm];

ϕ_A – strength factor of wall weakened by opening which is being strengthened, determined for the pattern curve A (see diagram in Figure 2.15) depending on dimensionless parameter $d / \sqrt{D_a(s_A - c)}$, and to determine this parameter, the value of s_A obtained in accordance with formulae 2.35 to 2.37 shall be taken;

d – diameter of the opening (inner diameter of a branch piece, sleeve) or the dimension of an oval or elliptical opening along the longitudinal axis, [mm].

For other symbols – see 2.8.2 and 2.10.1

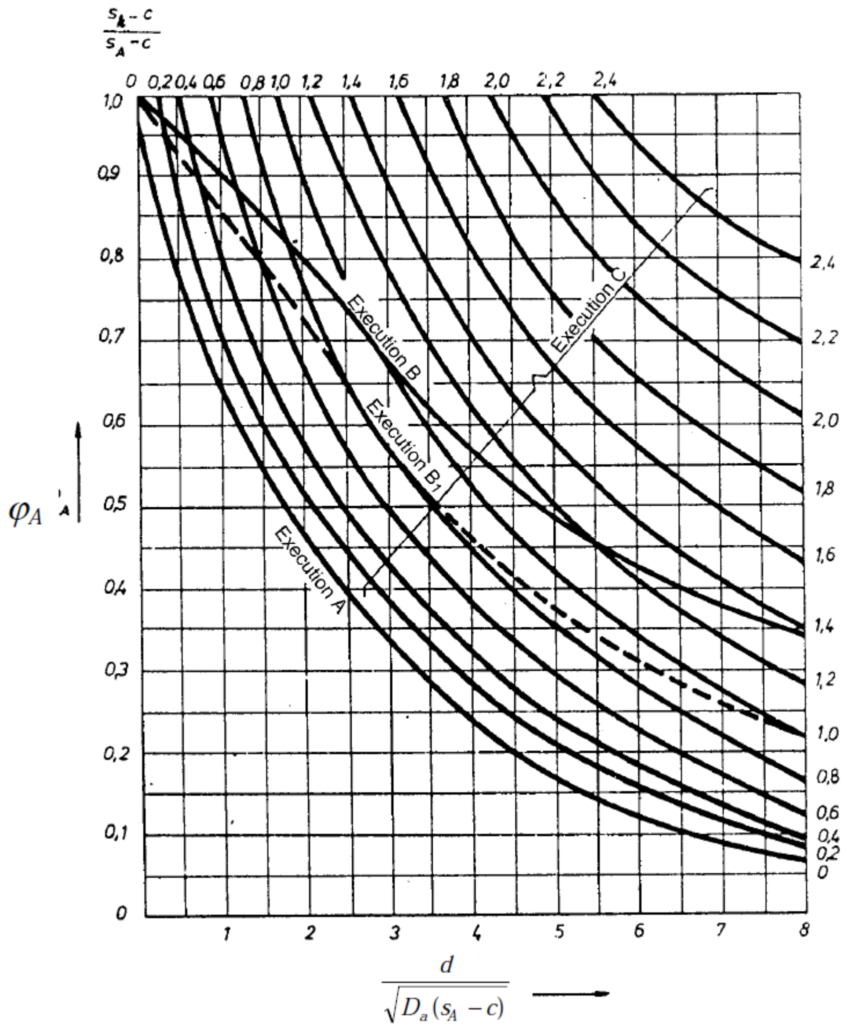


Figure 2.15

2.19.8 Where disc-shaped plates are used to strengthen openings in cylindrical, spherical or conical walls, the dimensions of the strengthening plates shall be determined in accordance with the following formulae:

$$b_b = \sqrt{D_a(s_A - c)},\; s_{b0} \geq s_A - s_r \qquad (2.38)$$

b_b – maximum effective width of the plate (see Figures 2.14-3 and 2.14- 4), [mm];

s_{b0} – plate thickness (see Figures 2.14-3 and 2.14-4), [mm];

s_A – total thickness of wall being strengthened and strengthening plate, determined in accordance with the requirements specified in 2.19.7, [mm];

sr – actual thickness of wall being strengthened, [mm].

For other symbols – see paragraph 2.19.7.

Where the actual width of strengthening plate is less than that resulting from formula 2.38, the plate thickness shall be increased respectively, in accordance with the formula below:

$$s_{br} \geq s_{b0}((1 + b_b / b_{br})/2) \quad (2.39)$$

s_{br} – actual thickness of plate, [mm];

b_{br} – actual width of the plate, [mm].

Thickness of weld seam connecting the strengthening plate to the wall shall not be less than 0.5 s_{br} (Figure 2.14-3).

2.19.9 Dimensions of welded tubular elements used to strengthen openings in cylindrical, spherical and conical walls shall not be less than those determined as follows:

.1 Wall thickness sk of a tubular element (branch piece, sleeve, etc.), [mm], shall be determined as a function of the following dimensionless parameter $d / \sqrt{D_a (s_A - c)}$ and the strength factor □A, from curves C shown in Figure 2.15. Quantities ϕ_r and sr shall be substituted for ϕ_A and s_A shown in Figure 2.15, where.

s_r – actual wall thickness, [mm];

ϕ_r – actual efficiency factor of a wall having thickness sr as determined by formulas 2.4, 2.5 and 2.10 by solving the equations of the said formulas for ϕ.

Ratio (S_k-C)/(S_A-C), determined from the diagram in Figure 2.15 shall be used to determine the minimum thickness s_k , [mm] of a branch piece or sleeve.

In this ratio, actual thickness sr shall be substituted for s_A.

.2 The minimum design height h_0 [mm] of a tubular strengthening element shall be determined in accordance with the formula below:

$$h_0 = \sqrt{d(s_k - c)} \quad (2.40)$$

If the actual thickness, h_r, of a tubular strengthening element is less than that determined in accordance with formula 2.40, thickness s_k shall be increased respectively as follows:

$$s_{kr} = s_k h_0 / h_r \quad (2.41)$$

2.19.10 Openings in dished ends shall be compensated for as follows:

.1 For openings strengthened by increasing the dished end wall thickness, factor y_A obtained from Table 2.8 shall be substituted for factor y in formula 2.26.

.2 For openings strengthened by means of disk-shaped strengthening plates, the plate dimensions shall be determined as required in paragraph 2.19.8, and the total thickness of the strengthened end wall, s_A , shall be determined in accordance with the formula below:

$$s_A = p(R_w + s) y_0 / 2\sigma\varphi_A + c \quad (2.42)$$

R_W – inner radius of curvature in the way of the opening, [mm];

y_0 – shape factor determined in accordance with Table 2.8;

For other symbols – see 2.16.1 and 2.19.7.

.3 The dimensions of tubular elements strengthening openings shall be determined in accordance with 2.19.9, except that the expression $2(0.5D_a + s)$ shall be substituted for Da in the following dimensionless parameter $d/\sqrt{D_a(s-c)}$ and the actual strength factor □ for the dished end wall thickness, s , shall be determined in accordance with formula 2.26, assuming $\phi = \phi_A$, $y = y_0$ and $s = s_A$ (see 2.16.1).

2.19.11 For through tubular strengthening elements with the inward projecting portion $h_m \geq s_r$ (Figures 2.14-5 and 2.14-6), thickness of the tubular element may be reduced by 20%, however its thickness shall not be less than that required for the design pressure.

2.19.12 The ratio of a tubular strengthening element thickness, s_k, to the thickness of wall being strengthened, s, shall not be greater than 2.4. If this ratio is taken as more than 2.4, for construction reasons, then tubular strengthening element thickness sk shall be assumed not greater than 2.4 times the thickness of the wall being strengthened in the calculation.

2.19.13 Disk-shaped strengthening plates and tubular strengthening elements may also be used in combination (Figure 2.16). In that case, the dimensions of strengthening elements shall be determined taking account of the requirements for both the disk-shaped and tubular strengthening elements.

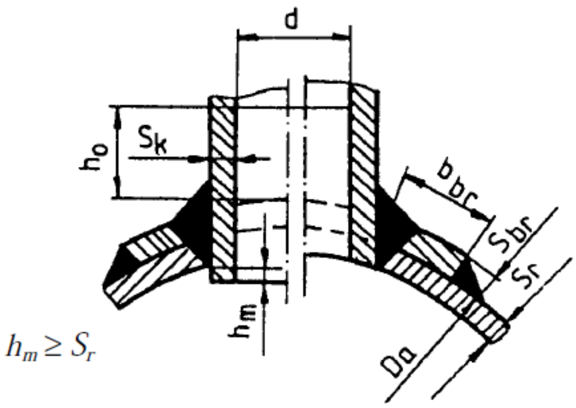


Figure 2.16

2.19.14 For branch pieces drawn from the wall being strengthened (Figure 2.14-7), thickness s_A shall not be less than that determined in accordance with formulae 2.35 to 2.42.

Strength factor ϕ_A for the wall weakened due to a drawn branch piece shall be obtained from diagram 2.15 as follows:

for $d/D_a \leq 0.4$ – from curve B,

for $d/D_a = 0.4$ – from curve B_1,

for $0.4 < d/D_a < 1.0$ – by interpolation of curves B and B_1.

For curves B and B_1 – see Figure 2.15 diagram.

Thickness of a drawn branch shoulder s_k shall not be less than that determined in accordance with the formula below:

$$S_k \geq S_A(d/D_a)[mm] \quad (2.43)$$

however not less than that required for the design pressure.

2.19.15 The effect of adjacent openings may be disregarded provided that:

$$(1 + s_{kr1} + s_{kr2}) \geq 2\sqrt{D_a(s_r - c)} \qquad (2.44)$$

$(1 + s_{kr1} + s_{kr2})$ – distance between two adjacent openings (Figures 2.17-1and 2.17-2), [mm];

D_a – outside diameter of wall being reinforced, [mm];

s_r – actual thickness of wall being reinforced, [mm];

c – design thickness allowance, [mm], (see 2.7).

Where $(1 + s_{kr1} + s_{kr2}) < \sqrt{D_a(s_r - c)}$, the stress occurring in the section between the openings due to design pressure shall be checked. Both longitudinal and lateral stresses in that section shall not exceed the allowable values determined in accordance with the formula below:

$$F / f_c \leq \sigma \qquad (2.45)$$

σ– allowable stress (see 2.4.5), [MPa];

F – load exerted by the design pressure upon the cross-section between openings (see 2.19.16), [N];

f_c – cross sectional area between openings (see 2.19.17), [mm^2].

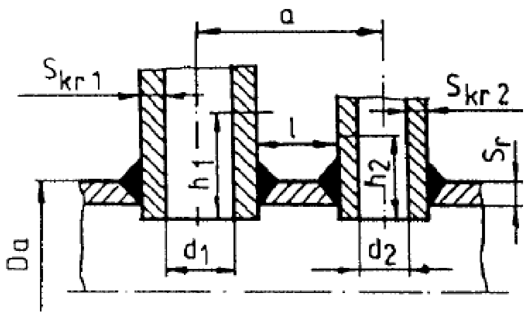


Figure 2.17-1

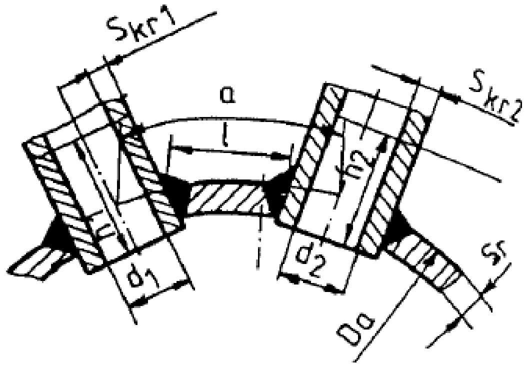


Figure 2.17-2

2.19.16 Load exerted by the design pressure on the cross-sectional area between two openings shall be determined as follows:

.1 for openings arranged longitudinally along a cylindrical wall:

$$F_a = Dpa / 2 \quad [N] \qquad (2.46)$$

.2 for openings arranged circumferentially in cylindrical or conical walls, as well as in the spherical walls:

$$F_b = Dpa / 4 \quad [N] \qquad (2.47)$$

.3 for openings in dished ends

$$F_b = R_B pay / 2 \text{ [N]} \quad (2.48)$$

a – spacing between two adjacent openings, measured at the outside circumference, as shown in Figure 2.17-2, [mm];

D – inside diameter (for conical walls measured at the centre of the opening), [mm];

p – design pressure, [MPa];

R_B – inner radius of curvature (see 2.19.10), [mm];

y – shape factor (see 2.16.1).

Where openings are arranged in cylindrical walls with a diagonal pitch, the load in question shall be determined in accordance with formula 2.47, and the obtained results shall be multiplied by the following factor:

$$K=1+\cos^2\alpha, \quad (2.49)$$

α– angle between the line of a row of openings and longitudinal axis, [deg].

2.19.17 For tubular strengthening elements, cross sectional area, f_c, [mm^2] between two adjacent openings shall be determined in accordance with the formula below:

$$f_c = l(s - c) + 0.5[h_1(s_{kr1} - c) + h_2(s_{kr2} - c)], \text{ [mm}^2\text{]} \quad (2.50)$$

h_1 and h_2 – height of strengthening elements, [mm], determined in accordance with the following formulae:

for blind strengthening elements: $h_{1,2} = h_0 + s$,

for through strengthening elements: $h_{1,20} = h_o + s + h_m$

l – width of bridge between two adjacent openings (Figures 2.17-1 and 2.17-2), [mm];

s – thickness of wall being reinforced, [mm];

s_{kr1} and s_{kr2} – thicknesses of tubular strengthening elements (Figures 2.17-1 and 2.17-2), [mm];

c – design thickness allowance, [mm], (see 2.7);

h_0 – design height of the tubular stiffener (see formula 2.40), [mm];

h_m – design height of tubular strengthening element projecting inwards (see Figures 2.14-5, 2.14-6 and 2.16), [mm].

For openings to be strengthened by other means (combined or disc-shaped strengthening elements, etc.), the values of fc shall be determined in accordance with the same procedure.

2.19.18 For drawn branch pieces arranged in a row, strength factor ϕ,

determined for this row in accordance with formula 2.1, shall not be less than strength factor ϕ_A , obtained from curves B and B_1 in Figure 2.15. For $\phi < \phi_A$, the value of ϕ shall be used to determine the wall thickness in accordance with 2.19.14.

This requirement also applies to welded branch pieces arranged in a row, whose thickness is determined only for the internal pressure effect.

2.20 Stays

2.20.1 Cross-sectional area of long and short stays, corner stays and stay tubes, subjected to tensile or compressive stresses shall not be less than that determined in accordance with the formula below:

$$f = pf_s / \sigma \cos\alpha \qquad (2.51)$$

f – cross-sectional area of single stay, [mm^2];

p – design pressure (see 2.2), [MPa];

σ – allowable stress (see 2.4.5), [MPa];

α– angle between the corner stay and the wall to which the stay is attached, [deg], (Figure 2.8);

f_s – maximum surface area of the wall to be reinforced per stay, [mm^2]. This area is bounded by lines passing at right angles through the centres of the lines interconnecting the centre of stay with the adjacent points of support (stays).

The cross-sectional area of the stays and tubes within this area may be determined according to the surface area per stay.

2.20.2 For stays subjected to bending, the allowable bending stress shall be determined with a safety factor not less than 2.25.

2.20.3 In the case of end plates with a single strengthening stay (Figure 2.18), the stay shall be so designed as to make it capable of bearing at least half the load acting on the end plate. Thickness of such an end plate shall fulfill the requirements specified in 2.12.1.

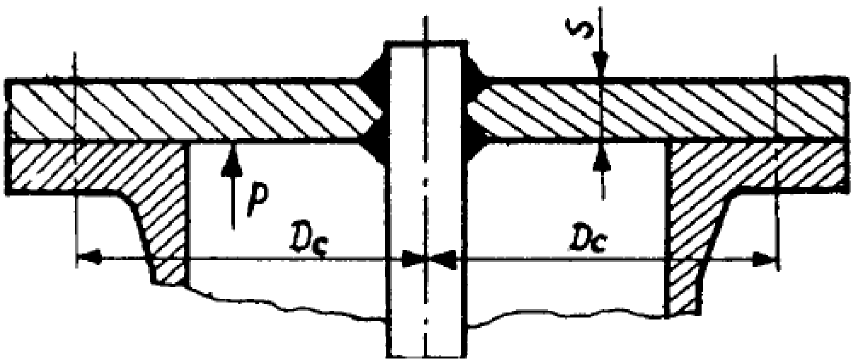


Figure 2.18

2.20.4 Stay and regular fire tubes shall have thickness not less than the values specified in Table 2.10.

Thickness of stay tubes with diameter over 70 mm shall not be less than:

6 mm – for peripheral tubes;

5 mm – for tubes arranged inside the tube nest.

Table 2.10

Outside diameter of tubes, [mm]	Tube wall thickness, [mm]			
	3.0	3.5	4.0	4.5
	Maximum working pressure, [MPa]			
50	1.10	1.85	–	–
57	1.00	1.65	–	–
63.5	0.90	1.50	2.10	–
70	0.80	1.35	1.90	–
76	0.75	1.25	1.75	2.25
83	–	1.15	1.60	2.10
89	–	1.05	1.50	1.90

2.20.5 Cross-sectional area of welds connecting stays shall be such as to fulfill the following requirement:

$$\pi d_a e / f \geq 1.25 \qquad (2.52)$$

d_a – stay diameter or outside diameter for tubes, [mm];

e – weld thickness , [mm];

f – cross-sectional area of the stay (see 2.20.1); [mm^2].

2.20.6 For flared tubes, the flared belt length in the tube plate shall not be less than 12 mm. The flared joints for working pressures above 1.6 MPa shall be made with sealing grooves.

2.20.7 Flared joints shall be checked for secure seating of the tubes in the tube plates by axial testing loads. The tubes may be considered securely seated, if the value obtained from the formula:

$$pf/20sl \qquad (2.53)$$

does not exceed:

15 – for joints of plain tubes,

30 – for joints with sealing grooves,

40 – for joints with tube flanging;

s – tube wall thickness, [mm];

l – flared belt length, [mm].

For other symbols – see 2.20.1.

The length of flared belt in tubes l shall not be taken greater than 40 mm.

2.20.8 The flared length of plain pipes shall be not less than that determined in accordance with the formula below:

$l = pf_s K_r / q$ [mm] (2.54)

K_r = 5.0 safety factor of flared joint,

p, f_s – see paragraph 2.20.1,

q – strength of pipe joint over 1 mm of flared belt, evaluated experimentally from the formula given below, [N/mm]:

$q=F/l_1$

F – axial force necessary to extract the flared tube from the tube plate, [N];

l_1 – length of flared belt used for experimental determination the of value of q [mm].

2.21 Top Girders

The section modulus of top girders with rectangular cross-section shall not be less than that determined in accordance with the formula below:

W=1000M/1.3σ Z (2.55)

W – section modulus for single girder, [mm^3],

σ– allowable stress (see 2.4.5), [MPa],

Z – rigidity factor for the wall being strengthened, for the structure as shown in Figure 2.19, z=1.33,

M – bending moment per one girder, [Nm]; for a rectangular section, the moment shall be determined in accordance with the formula below:

M= $pal^2/8000$ (2.56)

l – design length of the girder, [mm], (Figure 2.19),

p – design pressure, [MPa],

a – spacing between axes of adjacent girders, [mm],

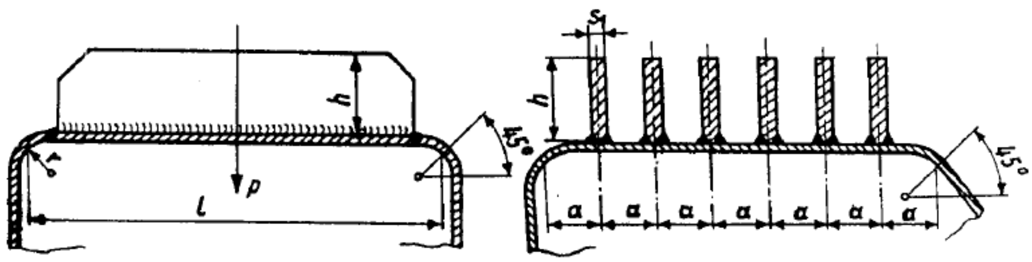


Figure 2.19

s_1 – width of girder, [mm], (Figure 2.19),

h – height of girder which shall not exceed $8s_1$ [mm], (Figure 2.19).

3 Boiler Design

3.1

3.1.1 Boilers shall be designed for the service conditions specified in the rules.

3.1.2 The thickness of tubes thinned in the process of bending shall not be less than the design value.

3.1.3 The use of long and short stays and of stay tubes exposed to bending or shearing stresses, shall be avoided. Stays, strength walls, stiffeners, etc., shall have no abrupt changes in cross sections.

Drilled holes shall be provided at short-stay ends.

3.1.4 For walls reinforced by short stays and exposed to flame and high temperature gases, the distance between stay centres shall not be larger than 200 mm.

3.1.5 In fire-tube boilers, corner stays shall be arranged at a distance of not less than 200 mm from the furnaces. Where flat walls are stiffened with welded girders, this shall be so done that the load involved is transferred, as far as possible, directly on to the boiler shell or the most rigid of its parts.

3.1.6 The distance between furnaces and boiler shell shall not be less than 100 mm. The distance between any two furnaces shall not be less than 120 mm.

3.1.7 Branch pieces installed to the boiler shall be of rigid construction and of minimum length sufficient for fixing and dismantling boiler mountings and fittings without removing the insulation. Branch pieces shall not be subjected to excessive bending stresses and shall be reinforced by stiffening fins if so required.

3.1.8 Flanges intended for installation of mountings, fittings and piping, as well as branches and sleeves passing through the entire thickness of the boiler wall shall be attached by welding, preferably from both sides. Branch pieces may also be welded from one side, using removable backing strip or by some other method that ensures penetration throughout the entire thickness of the boiler wall.

3.1.9 Boiler drums and headers of wall thickness greater than 20 mm, as well as superheated headers shall be protected from direct heat radiation, unless conditions specified in 2.3.4 are met.

It is recommended that the gas uptake pipes of vertical fire-tube boilers passing through the steam space of the boiler be protected from direct exposure to hot gases.

3.1.10 Where use is made of non-metal sealing gaskets for closures of manholes and other openings, the design shall prevent the possibility of gaskets being forced out.

3.1.11 Suitable design provisions shall be made to prevent steam formation in economizers of boilers.

3.1.12 A name-plate including all principal particulars of the boiler shall be provided in a visible place on the boiler.

3.1.13 The fastening elements on boilers, except for the elements not being under load, shall not be welded directly to the boiler shells but shall be attached to the welded pads.

3.1.14 Tubes flue rolled on headers and tube plates shall be of seamless type.

3.1.15 Boilers with finned pipes shall be accessible for inspection from the flame side and shall be fitted with effective soot blowers.

3.2 Boilers Mountings, Fittings and Gauges – General Requirements

3.2.1 All boiler mountings shall be fitted on special welded branches, nozzles or pads, and be secured to these, as the rule, by flanged joints. The studs shall have a full thread holding in the pad for a length at least one external diameter of the thread. Screwed joints are allowed for mountings in a range of bores up to 15 mm.

The construction of welded pads, branches and nozzles shall fulfil the requirements specified in 2.19.

3.2.2 Valve covers shall be secured to valve cases by studs or bolts. Valves with bore diameters of 32 mm and less may have screwed joints provided that there are means preventing them from being loosened.

3.2.3 Valve covers and cocks shall be fitted with ”on” and ”off” position indicators. Position indicators are not required where the design allows to see without difficulty whether the fittings are open or shut.

Valves shall be so designed as to be capable of being shut with clockwise motion of the wheels.

3.3 Feed Valves

3.3.1 Each main boiler and each auxiliary boiler for essential services shall be equipped with at least two feed valves. Auxiliary boilers for other services, and also waste-heat boilers may have one feed valve each.

3.3.2 Feed valves shall be of non-return type. A shut-off valve shall be installed between the feed valve and the boiler. The non-return and shut-off valves may be housed in one casing. The shut-off valve shall be fitted directly to the boiler.

3.3.3 The requirements concerning the feed water system to be observed.

3.4 Water Level Indicators

3.4.1 Every boiler with a free water surface shall be provided with at least two independent water level indicators with reflecting glass (see paragraph 3.4.3).

Subject to ACS acceptance in each particular case, one of water level indicators may be replaced by:

- suitable safety and indication means of lower and upper water level; (safety and indication sensors shall be independent), or
- remote, independent water level indicator of an approved type.

Boilers of a capacity below 750 kg/h, as well as all steam heated steam generators and waste-heat boilers with free water evaporating surface and steam reservoirs (steam separators) may be provided with single water level indicators with reflecting glass.

3.4.2 Forced circulation boilers shall be provided with two independent alarms to signal a shortage of water flow. The second alarm is not required, provided the requirements concerning the control systems are fulfilled. This requirement does not apply to waste-heat boilers.

3.4.3 Flat prismatic reflecting glass shall be used in water level indicators for boilers with a working pressure of less than 3.2 MPa. For boilers having a working pressure of 3.2 MPa and upwards, sets of mica sheets shall be used instead of glass, or else plain glass with a mica layer to protect the glass from water and steam effects, or some other materials resistant to destructive action of the boiler water.

3.4.4 The water level indicators shall be fitted vertically on front of the boiler, at an equal and possibly shortest distance from the vertical centre plane of the drum.

3.4.5 Water level indicators shall be provided with shut-off valves both on the water and steam side. The design of the shut-off valve shall provide for the safe cut-off of water flow in case of glass crack.

3.4.6 Water level indicators shall have the possibility of separate blowing-off the water and steam spaces. Blow-down valves shall have an inside diameter of not less than 8 mm. The design of water level indicator head shall prevent the gasket material from being forced into the ducts by the boiler pressure and shall allow for replacing the glasses while the boiler is in operation.

3.4.7 Water level indicators shall be so installed that the lower edge of slot in the indicator frame is positioned at least 50 mm below the lowest water level in the boiler, the centre line of indicator frame slot (centre of sight) being above the lowest water level.

3.4.8 Water level indicators shall be connected to the boiler by means of independent branch pipes. No tubes leading to these branches are allowed inside the boiler. The branches shall be protected from exposure to hot gases, radiant heat and intense cooling.

If the gauge glasses are fitted on hollow casings, the space inside such gauges shall be divided by partitions.

Water gauges and their branch pipes shall not be allowed to carry nozzles or branch pieces to be used for other purposes.

3.4.9 The branch pieces for attachment of water level indicators to boilers shall have an inside diameter not less than:

32 mm – for bent branches of main boilers;

20 mm – for straight branches of main boilers and for bent branches of auxiliary boilers;

15 mm – for straight branches of auxiliary boilers.

3.4.10 The design, dimensions, number, location and lighting of water level indicators shall provide for adequate visibility and reliable control of the boiler water level. Where water level visibility is inadequate, irrespective of the height of water level indicator location, or where the boilers are remotely controlled, provision shall be made for highly reliable remote water level indicators (placed at lower position) or other types of water gauges approved by ACS. This requirement does not apply to waste-heat boilers and their steam receivers.

3.4.11 The indication error of the remote water level indicators shall not be greater than ±20 mm as compared to the indications of water level indicators fitted directly on the boiler. The difference in their simultaneous indications at the maximum possible rate of level changes shall not exceed 10% of the distance between the lower and the upper level.

3.5 Marking of Lowest Water Level and Highest Heating Surface Points

3.5.1 Each boiler with free water surface (evaporating surface) shall have its lowest water level marked on the boiler water level indicator with a reference line drawn on the gauge frame or body. Additionally, the lowest water level shall be marked on a special plate in the form of horizontal reference line with inscription „lowest water level". The plate shall be fitted to the boiler shell close to the water level indicators.

The lowest level reference line, as well as the plate shall not be covered with boiler insulation.

3.5.2 The lowest water level in the boiler shall not be less than 150 mm above the highest heating-surface point. This distance shall also be maintained when the ship is listed up to 5o to any side and under all possible trims in normal service conditions.

In the case of boilers with design capacity less than 750 kg/h, the said minimum distance between the lowest water level and the highest point of heating surface may be reduced down to 125 mm.

3.5.3 The position of the upper ends of the uppermost downcomers is assumed to be the highest point of heating surface of water-tube boilers.

For vertical fire-tube boilers with the fire tubes and gas uptake pipes passing through the steam space of the boiler, the determination of the highest heating surface point will be specially considered by ACS in each particular case.

3.5.4 Each fire-tube boiler shall be fitted with a position indicator for the highest heating-surface point, which shall be attached to the boiler wall close to the lowest water-level plate, and to have an inscription "highest heating-surface point".

3.5.5 The requirements concerning the position of the highest heating-surface point and the relevant position indicator do not apply to waste-heat boilers, forced circulation boilers, economizers and steam superheaters.

3.6 Pressure Gauges and Thermometers

3.6.1 Each boiler shall have at least two pressure gauges connected to the steam space by separate pipes fitted with stop valves or stop cocks. Three-way valves or cocks shall be provided between the pressure gauge and pipe, thus making it possible to shut off the pressure gauge from the boiler, blow off the connecting pipe with boiler steam and install the control pressure gauge.

3.6.2 One of the pressure gauges shall be installed on the front of the boiler and the other in main engine control station.

3.6.3 Boilers with the design capacity below 750 kg/h and waste-heat boilers are allowed to have one pressure gauge.

3.6.4 A pressure gauge shall be provided at the feed water economizer.

3.6.5 Pressure gauges shall have a scale sufficient to allow for boiler hydraulic testing.

The pressure gauge scale shall have a red line to mark the working pressure in the boiler.

3.6.6 Pressure gauges shall be installed on the boilers in such a way that they are suitably protected from the heat emitted by non-insulated boiler surfaces.

3.6.7 Steam superheaters and economizers shall be equipped with thermometers with suitable range.

Where remote temperature control is installed the local thermometers shall also be fitted.

3.7 Safety Valves

3.7.1 Each boiler shall have not less than two spring-loaded safety valves of identical construction and equal diameter of cross-sectional area, to be installed on the drum, as a rule, on a common branch piece; additionally one valve shall be fitted on the superheater outlet header. The superheater safety valve shall be so adjusted as to open before the safety valve installed on the drum.

Safety valves of non direct-acting type are recommended for steam boilers having a working pressure of 4 MPa and more.

One safety valve is sufficient for steam boilers with design capacity below 750 kg/h, as well as for waste-heat boilers and their steam reservoirs (steam separators).

3.7.2 Aggregate cross-sectional area, f, of safety valves shall not be less than that determined in accordance with the formula below:

for saturated steam

$$f = KG/(10.2 p_w + 1) \quad [\mathrm{mm}^2] \qquad (3.1)$$

for superheated steam

$$f = K\frac{G\sqrt{V_H / V_S}}{(10.2 p_w + 1)} \quad [\mathrm{mm}^2] \qquad (3.2)$$

f – aggregate cross-sectional area of safety valves, [mm^2];

G – design capacity, [kg/h];

p_w – working pressure, [MPa];

V_H – specific volume of superheated steam at the appropriate working pressure and temperature, [m^3/kg];

V_S – specific volume of saturated steam at the appropriate working pressure and temperature, [m^3/kg];

K – factor as per Table 3.1.

Table 3.1

Valve Lift	K factor
$d/20 \le h < d/16$	22
$d/16 \le h < d/12$	14
$d/12 \le h < d/4$	10.5
$d/4 \le h < d/3$	5.25
$d/3 < h$	3.3

d – minimum diameter of valve, [mm];

h – valve lift, [mm].

Safety valves shall not be less than 32 mm or more than 100 mm in diameter.

If specially approved by ACS, the use of valves with smaller areas than required in accordance with formulae 3.1 and 3.2 may be allowed, provided it is proved experimentally that each of these valves has a discharge capacity not lower than the design steam capacity of the boiler.

3.7.3 The cross-sectional area of the safety valve installed on the nondisconnectable superheater may be included in the aggregate area of the valves to be determined in accordance with formulae 3.1 and 3.2. This area shall not amount to more than 25% of the aggregate cross-sectional area of the valves.

3.7.4 The safety valves shall be so adjusted that the valve operating pressure does not exceed the design pressure. Safety valves of main and auxiliary boilers of essential services, after being lifted shall stop the steam escape at the pressure not less than 0.85 of the working pressure.

3.7.5 Each flue gas heated economizer shall be provided with spring-loaded safety valve not less than 15 mm in diameter.

3.7.6 Where safety valves are fitted on a common branch, the cross-sectional area of the branch shall not be less than 1.1 times the aggregate cross-sectional area of the valves installed.

3.7.7 The cross-sectional area of the outlet steam branch of the safety valve, as well as of the pipe connected thereto, shall not be less than twice the aggregate area of the valves.

3.7.8 To remove the condensate, a drain pipe without any stopping devices shall be provided on the valve body or on the outlet steam pipe if it is located below the valve.

3.7.9 The safety valves shall be connected directly to the boiler steam space without any stopping devices.

Supply pipes leading to the safety valves are not allowed to be installed inside the boiler, nor can any provision be made on the safety valve bodies or their connections for steam extraction or for other purposes.

3.7.10 The safety valves shall be so arranged that they can be lifted by a special hand-operated easing gear. The easing gear shall be operated from the boiler room, and from the upper deck or any other readily accessible place outside the boiler room.

The remote control gear for safety valves of steam superheaters, waste-heat boilers and their steam tanks (separators) shall be operated only from the boiler room.

3.7.11 The safety valves shall be so designed that they can be sealed or provided with an equivalent safeguard to make it impossible for the valves to be readjusted without the knowledge of the personnel.

The springs of the safety valves shall be protected from direct exposure to steam; these springs, as well as the sealing surfaces of seats and valves shall be made of heat- and corrosion-resistant materials.

3.8 Shut-off Valves

3.8.1 Each boiler shall be separated from all pipelines leading to it by means of shut-off valves secured directly to the boiler.

3.8.2 Stop valves of the main and auxiliary steam lines shall be provided with remote control gear for the operation from the upper deck or from other readily accessible position outside the boiler room.

3.8.3 Where a single main boiler or a single auxiliary boiler of essential services is installed on board, the superheater and economizer shall be so arranged as to be capable of being shut-off from the boiler.

3.9 Blow-down Valves

3.9.1 Boilers shall be fitted with blow-down and scum arrangements and, where necessary, with drain valves.

Blow-down and drain valves shall be fitted directly to the boiler shell.

For boilers of working pressure lower than 1.6 MPa, these valves may be installed on welded-on branch pieces.

Steam superheaters, economizers and steam accumulators shall be provided with blow-down valves or drain valves.

3.9.2 The inside diameter of blow-down valves and pipes shall not be less than 20 mm or more than 40 mm. For boilers with design capacity below 750 kg/h, the inside diameter of the valves and pipes may be reduced down to 15 mm.

3.9.3 The scum arrangements in boilers with a free water surface (evaporating surface) shall be such as to ensure scum and sludge removal from the entire evaporating surface.

3.10 Salinometer Valves

Each boiler shall be provided with at least one salinometer valve or cock.

Installing such valves or cocks on pipes and branches intended for other purposes is not allowed.

3.11 Deaeration Valves

Boilers, superheaters and economizers shall be equipped with sufficient number of valves or cocks for deaeration.

3.12 Openings for Internal Inspection

3.12.1 Boilers shall be provided with manholes for inspection of internal surfaces. Where the arrangement of manholes is not possible, provision shall be made for sight holes.

3.12.2 Manhole openings shall have dimensions not less than:

300 x 400 mm – for oval openings, or

400 mm – for round openings.

In separate cases, if specially approved by ACS, the dimensions of manhole openings may be reduced to 280 x 380 mm for oval and 380 mm for round openings.

The oval manhole openings in cylindrical shells shall be positioned in a way that the minor axis of the manhole is arranged longitudinally.

3.12.3 Vertical fire-tube boilers shall have at least two sight holes arranged opposite to each other in the area of the working water level.

3.12.4 All boiler parts such as may prevent or hinder free access to and inspection of internal surfaces shall be of removable type.

3.13 Incinerating Boilers

3.13.1 These provisions apply to auxiliary boilers utilized for incinerating garbage and oil wastes of flash point above 60 oC.

3.13.2 Automatic control systems of incinerating boilers shall fulfil the relevant requirements.

3.13.3 Special furnace chamber shall be provided for incineration of garbage and oil wastes, the chamber shall fulfil the following requirements:

.1 the chamber shall be entirely separated from the boiler furnace and lined with material resistant to chemical effects of incinerated products;

.2 ducts interconnecting the furnace with chamber shall have sufficient crosssectional area. In all the cases the working pressure in the chamber shall not exceed the furnace pressure by more than 10%;

.3 a safety device, activated when the working pressure is exceeded by 0.02 MPa, shall be provided preventing outburst of flame into the boiler-engine room;

.4 aggregated free cross-sectional area of the safety device shall be not less than 115 cm^2 per 1 m^3 of the chamber volume, however not less than 45 cm^2;

.5 the chamber charging device shall be such as to prevent the simultaneous opening. Any limitations concerning the garbage incinerating shall be posted on the warning plate;

.6 chambers provided for incineration of garbage only can be installed in the boiler furnace;

.7 if no garbage dump bunker is provided, the chute cover shall be provided with locking device preventing its opening in case the temperature inside the chamber could cause self-ignition of the garbage.

3.13.4 Oil wastes are, in general, to be incinerated in special system designed for this purpose. It is possible to use for this purpose the boiler firing system including the burner, provided that smokeless incineration is ensured as far as possible.

3.13.5 Incinerating boilers shall be provided with effective system of soot removal.

3.14 Thermal Oil Heaters

3.14.1 The provisions of this Section refer to heaters for thermal oils. Thermal oil heaters are, in general, to be installed in separate spaces, equipped with exhaust ventilation, capable to perform at least 6 air changes per hour.

3.14.2 Thermal oil heaters shall be so designed as to eliminate a possibility of thermal oil overheating above its upper permissible temperature limit in the case its burners and thermal oil circulating pumps are stopped.

The maximum working temperature of given thermal oil shall be maintained at least 50°C below its upper permissible temperature limit.

3.14.3 The construction of combustion chambers and burners shall secure uniform heat distribution.

Only such non-uniformity of heat distribution may be admitted at which the temperature in thermal oil boundary layer at any place of the heating surface does not exceed the upper allowable temperature limit for the thermal oil used.

The construction of combustion chamber and location of burners shall prevent direct exposure of the heater surface to the flames. The burner shall be so designed as to eliminate the heat delivery above its nominal rate.

The combustion chambers of thermal oil heaters with the capacity of 1000 kW and more shall be provided with hermetization devices and a separate smothering system of type approved by ACS.

3.14.4 Each thermal oil heater shall be fitted with:

- shut-off valves at inlet and outlet of thermal oil. Such valves of oil fired and exhaust gas fired thermal oil heaters shall be controlled from outside the compartment in which they are situated. Alternatively an arrangement for quick gravity drainage of the thermal oil, contained in the oil system, into a draining tank is acceptable provided that the specific requirements are fulfilled;
- pressure gauge;
- at least two spring-loaded safety valves of closed type, of identical construction and dimensions, the throughput of each one being not less than the capacity of circulating pump. The cross-sectional area of safety valves shall not be less than that corresponding to the diameter of 32 mm and not greater than that corresponding to the diameter of 100 mm;
- arrangements for taking samples of thermal oil;
- inspection openings in accordance with 3.12.

3.14.5 Each thermal oil heater shall be equipped with effective means for soot removal.

3.14.6 Thermal oil heater tubes shall be connected to headers and chambers by welding.

3.14.7 Bellows type valves shall be applied to thermal oil boilers. Application of gland type fittings is subject to ACS acceptance in each particular case.

3.14.8 Thermal oil heaters shall be provided with alarm and safety system activated at limit temperatures of thermal oil and exhaust gas, fitted at the outlet of the heaters.

3.14.9 Thermal oil heaters shall be provided with automatic combustion control, audible and visual alarm, interlock device in accordance with the requirements specified in paragraph 5.2.1, as well as protective device as specified in paragraph 5.2.2.

3.15 Water Heating Boilers

Construction and materials of water heating boilers shall fulfill the requirements for steam boilers.

3.16 Additional Requirements for Waste-heat Boilers

3.16.1 Waste-heat boilers shall be fitted with devices closing the supply of hot gas to the boiler in the case of alarm system activation.

3.16.2 The boiler shall be so designed and installed that all tubes can be easily and readily inspected for any signs of corrosion and leakage.

3.16.3 The boiler shall be fitted with temperature sensor(s) and fire detection alarm.

3.16.4 A fixed fire extinguishing and cooling systems shall be fitted. A sprinkler system of sufficient capacity may be accepted.

The exhaust duct below the boiler shall be so arranged for adequate collection and drainage of any fluid as to prevent it from flowing into the diesel engine. The collected fluid shall be properly drained.

3.16.5 Except for the case mentioned in paragraph 3.16.6.1, only one safety valve may be installed on waste-heat boilers.

3.16.6 Waste-heat boilers that may be isolated from the steam plant system in a flooding condition shall fulfil the following requirements:

.1 shell type boilers having a total heating surface of 50 m^2 or more shall be provided with at least two safety valves,

.2 shell type boilers shall be provided with removable lagging at the circumference of the tube end plates to enable ultrasonic examination of the tube plate to shell connection,

.3 the manufacturer shall provide operating instructions for each boiler which shall include reference to:

- feed water treatment and sampling arrangements,
- operating temperatures – exhaust gas and feed water temperatures as well as operating pressure,
- inspection and cleaning procedures,
- records of maintenance and inspection,
- the need to maintain adequate water flow through the boiler under all operating conditions,
- periodical operational checks of the safety devices to be carried out by the operating personnel and to be documented accordingly,
- procedures for using the waste-heat boiler in the dry condition,
- procedures for maintenance and overhaul of safety valves.

4 Control, Safety and Alarm Systems of Boilers

4.1 General Requirements

4.1.1 The requirements specified this Chapter apply to permanently attended boilers.

The requirements for control system, alarm system and safety system of unattended boilers are specified in Part 4, Chapters 3 and 4, Electrical Installations and Control Systems.

4.2 Control Systems

4.2.1 Main water-tube boilers and auxiliary water-tube boilers of essential services shall be provided with feed and combustion automatic control systems.

It is recommended that other boilers be also provided with such control systems.

4.2.2 The control systems shall be capable of maintaining the water level, steam pressure and other variable parameters within the predominated limits over the entire load range and to ensure quick changes of boiler load.

4.3 Safety Systems

4.3.1 The boilers shall be provided with non-detachable system ensuring the water level in the boiler (see 3.5) not to fall beneath the lowest permissible level.

4.3.2 The boilers with automatic control of combustion shall be provided with a safety system in accordance with the requirements specified in 5.2.

4.4 Alarm Systems

4.4.1 Boilers with automatic control of feed and combustion shall be provided with audible and visual alarm system at the control stand.

4.4.2 The audible and visual alarms shall be activated in the case of:

- the water level reaching its lowest limit,
- the water level reaching its highest limit,
- failures in the automatic control and safety systems,
- failures in the boiler firing installations (see paragraph 5.2.3),
- salinity of feed water exceeding the permissible level

4.4.3 The lowest water level alarms of the main boilers and auxiliary boilers of essential services shall be activated prior to the activation of the safety system.

4.4.4 Provision shall be made for the audible alarm to be switched off manually after its activation.

5 Oil Fuel Installations of Boilers

5.1 General Requirements

5.1.1 All the components of oil fuel installation such as pumps, fans, quick closing valves and electric drives, shall be of type approved by ACS and shall be manufactured and tested under the survey of ACS or other competent technical inspection body.

Electric equipment, control, safety and alarm systems shall fulfill the relevant requirements specified in Chapters 3 and 4, Electrical Installations and Control Systems.

Piping systems and fittings of oil fuel installation shall fulfil the relevant requirements specified in Chapter 11.

5.1.2 The requirements specified in this Chapter apply to the equipment for firing the boilers with fuel oil of flash point not less than 60°C.

Where crude oil or slops are used as the fuel for tanker boilers, then, the furnaces and smoke uptake pipes shall be gastight and tested for gas tightness before being taken in use.

5.1.3 Burners shall be so designed as to ensure the possibility for the control of the flame jet size and shape.

5.1.4 In the case of variable-delivery burners, provision shall be made to control the amount of combustion air.

5.1.5 Proper design solutions shall be applied to preclude the possibility of turning and removing the burners from their positions before cutting-off the fuel supply.

5.1.6 Where the fuel is atomized by means of steam or air, the construction of burners shall preclude the possibility of penetration of steam or air to fuel oil and vice versa.

5.1.7 Where fuel preheating is applied, provision shall be made to preclude the possibility of fuel overheating when the boiler capacity has been reduced or the burners have been cut off.

5.1.8 Proper drip trays shall be provided where fuel leaks may be expected.

5.1.9 Proper sight glasses shall be provided to monitor the combustion process in the furnace. Means shall be provided to prevent flame and hot air outburst when the burner is removed.

5.1.10 Proper arrangement shall be provided for the storage and smothering of the manual ignition torch.

It is recommended that the inlets of boiler fans be protected against penetration of moisture and solids.

5.2 Additional Requirements for Permanently Attended Boilers with Automatic Firing Control

5.2.1 Firing installations of boilers shall be provided with an interlock to enable the fuel supply to the furnace only when the following conditions are fulfilled:

.1 the burner is in the operating position,

.2 all electrical equipment is connected to the power supply,

.3 air is fed to the boiler furnace,

.4 the pilot burner is alight or electrical ignition switched on,

.5 the water level in boiler is normal.

In general, the shut-off of fuel supply shall be effected by two self-closing valves connected in series. Where the daily service tank is situated below the furnace, one such valve is sufficient.

5.2.2 Firing installations of boilers shall be fitted with non-detachable protective devices to operate within 1 second maximum (in the case of a pilot burner within 10 seconds maximum) and automatically shut off fuel supply to the burners in case of:

.1 low pressure of combustion air or decay of combustion air flow,

.2 burner flame failure,

.3 water level in the boiler reaching its lower limit.

Activation of protective devices shall actuate visual and audible alarms.

5.2.3 Firing installations shall be equipped with a burner flame jet monitor.

Such monitor shall respond only to the flame of the burner under control.

5.2.4 Capacity of the pilot burner shall be such that the burner is not capable of maintaining, by itself, the boiler under working pressure even with the steam consumption stopped.

If the pilot burner and the main burner are simultaneously in operation and the safety system is activated in the cases mentioned in paragraph 5.2.2, both burners shall stop their operation at the same time.

5.2.5 Firing installation of the main and auxiliary boilers of essential services shall be capable of being started up and controlled manually. Manual control arrangements shall be located as close to the boiler as possible.

While the firing installation is being manually controlled, all the automatic control arrangements mentioned in paragraphs 5.2.1 and 5.2.2 shall be in operation.

5.2.6 Provision shall be made for the firing installation to be shut off from two different stations, one of which shall be situated outside the boiler room.

6 Pressure Vessels And Heat Exchangers

6.1 Construction of Pressure Vessels and Heat Exchangers

6.1.1 Components of pressure vessels and heat exchangers being in contact with sea water or other possibly corrosive media shall be constructed from corrosion-resistant materials. In the case of other materials, the method of their protection against corrosion is subject to ACS acceptance in each particular case.

6.1.2 Construction of pressure vessels and heat exchangers shall provide their reliable in the conditions specified in the rules.

6.1.3 Pressure vessels and heat exchangers shall fulfill the requirements specified in 3.1.2, 3.1.3, 3.1.4, 3.1.7, 3.1.8, 3.1.10, as well as 2.2.14 and 2.2.19.

6.1.4 Where necessary, construction of pressure vessels and heat exchangers shall take account of possible thermal expansion of the shell and other components.

6.1.5 Shells of heat exchangers and pressure vessels shall be fixed to their seatings by supports. Upper fixing arrangements shall be provided if necessary.

Construction of the fixing arrangements for pressure vessels and heat exchangers to the foundations shall also take account of the rules requirements.

6.2 Fittings and Gauges

6.2.1 Pressure vessels and heat exchangers or their inseparable sets shall be fitted with non-disconnectable safety valves. In the case of several non-interconnected spaces, safety valves shall be provided for each space.

Hydrophore tanks shall be fitted with safety valves located on the waterside.

In justified cases, ACS may waive the above-mentioned requirements.

6.2.2 In general, safety valves shall be of a spring-loaded type. Safety diaphragms of a type approved by ACS are permitted in fuel and oil heaters provided they are installed on the fuel and oil side.

6.2.3 The discharge capacity of safety valves shall be such that under no conditions the working pressure is exceeded by more than 10 %.

6.2.4 Safety valves shall be so designed as to be capable of being sealed or fitted with an equivalent means to prevent their unauthorized adjustment.

Materials used for springs and sealing surfaces of valves shall be resistant to corrosive effect of the medium.

6.2.5 Level indicators and sight glasses may only be installed on pressure vessels and heat exchangers where required by the conditions of control and inspection. Level indicators and sight glasses shall be of reliable construction and protected adequately. For steam, oil and refrigerants, flat glass plates shall be used for level indicators and sight glasses.

6.2.6 Pressure vessels and heat exchangers shall be provided with flanges or flanged branch pieces for installation of fittings and mountings.

In hydrophore tanks, threaded branch pieces may also be applied.

6.2.7 Pressure vessels and heat exchangers shall be provided with adequate blowdown arrangements as well as drain arrangements.

6.2.8 Pressure vessels and heat exchangers shall be provided with manholes for internal examination. Where the manholes are impracticable, adequate sight holes shall be provided. Pressure vessels and heat exchangers with more than 2.5 m in length shall be provided with the inspection holes at both ends.

Where the pressure vessel or heat exchanger is of dismountable construction or where corrosion and contamination of internal surfaces is precluded, manholes or inspection holes are not required.

Manholes or sight holes are not required where the construction of pressure vessel or heat exchanger precludes the possibility of inspection through such holes.

For the dimensions of manholes' openings – see paragraph 3.12.2.

6.2.9 Pressure vessels and heat exchangers, as well as their inseparable units shall be equipped with a pressure gauge or a compound pressure gauge. In heat exchangers divided into several spaces, a pressure gauge or a compound pressure gauge shall provided for each space.

Pressure gauges shall fulfil the requirements specified in 3.6.1 and 3.6.5.

6.2.10 Fuel heaters where the fuel temperature may exceed 220° C shall be fitted – apart from the temperature controller – also with sensor warning about high temperature or stopped flow of fuel.

6.3 Requirements for Particular Types of Pressure Vessels and Heat Exchangers

6.3.1 Air Receivers

6.3.1.1 Safety valves of starting air receivers for main and auxiliary engines, as well as of fire protection systems, after being lifted, shall completely stop the air escape at the pressure inside the receiver not less than 0.85 of the working pressure.

6.3.1.2 Where air compressors, reducing valves or pipes from which air is supplied to the receivers are provided with safety valves so adjusted to prevent the receivers from being supplied with air of the pressure higher than the working pressure, safety valves need not be fitted on such receivers. In that case, fusible plugs shall be fitted on the receivers instead of the safety valves.

6.3.1.3 The fusible plugs shall have a fusion temperature within 100 – 130° C.

The fusion temperature shall be permanently marked on the fusible plug. Air receivers having a capacity over 0.7 m^3 shall be fitted with plugs not less than 10 mm in diameter.

6.3.1.4 Air receivers shall be equipped with water-draining arrangements.

In air receivers positioned horizontally, the water draining arrangements shall be installed at both ends of the receiver.

6.3.2 Cylinders for Compressed Gases

6.3.2.1 Cylinders for compressed gases are portable pressure vessels designed for the storage of compressed gaseous refrigerants or CO_2, which are stored on board the ship for her operational purposes, but are incapable of being filled by means of the ship's equipment.

6.3.2.2 Strength calculations shall be performed in respect of the requirements specified in 2.8 and the following:

- design pressure shall not be less than the pressure which may occur at temperature 45 oC, at the predetermined filling level;
- allowable stress σ shall be determined in accordance with 2.4, whereas the safety factor in accordance with 2.5.1;
- allowancec for cylinders being exposed to corrosion shall not be taken less than 0.5 mm.

Cylinders may be made of steel with the yield stress greater than 750 MPa but not exceeding 850 MPa subject to ACS acceptance in each particular case.

6.3.2.3 Non-disconnectable safety devices of approved construction shall be provided to prevent a dangerous overpressure in the cylinder in case of temperature increase. Safety valves or burst disks activated at a pressure exceeding 1.1 times the working pressure but not higher than 0.9 times the test pressure are permitted.

6.3.2.4 Cylinders shall be permanently marked to include the following information:

.1 manufacturer's name,

.2 serial number,

.3 year of manufacture,

.4 kind of gas,

.5 capacity,

.6 test pressure,

.7 tare,

.8 maximum load (pressure/weight),

.9 stamp and date of testing.

6.3.2.5 Cylinders shall be hydraulically tested under pressure equal to 1.5 times the working pressure.

6.3.2.6 Cylinders which are designed for the storage of compressed gases, refrigerants or extinguishing agents shall be approved by ACS or shall be manufactured in accordance with the relevant standards under the survey of a competent technical inspection body approved by ACS.

6.3.3 Condensers

6.3.3.1 Construction of condensers and their location on board shall be such as to enable tube replacement.

In general, the main condenser shell shall be of steel welded construction.

Baffles shall be provided inside condensers, at excess pressure steam inlets, to protect the tubes from the direct steam impact.

Tube fixing shall be so designed as to prevent sagging and dangerous vibration of the tubes.

6.3.3.2 Covers of condenser water chambers shall be provided with manholes in a number and position as may be required to ensure access to the tubes for the purposes of flaring, packing replacement or plugging of any tube.

Cathodic protection shall be provided to prevent electrolytic corrosion of the water chambers, tube plates and tubes.

6.3.3.3 The main condenser shall be capable of operating in emergency conditions with any turbine casing detached.

6.3.3.4 Construction of condenser shall enable fixing of monitoring and measuring devices.

6.3.4 Pressure Vessels and Heat Exchangers of Refrigerating Installations

The requirements specified in 6.1, 6.2, 6.3.2 and 6.3, except for paragraphs 6.3.3.3 and 6.3.3.4, apply to pressure vessels and heat exchangers of the refrigerating and fire extinguishing installations, whereas the requirements specified in 6.2.1 may be considered as guidelines.

6.3.5 Pressure Vessels for Processing Fishery Products

6.3.5.1 Pressure vessel covers opened periodically shall be fitted with devices preventing a partial closing or spontaneous opening of the covers. Provision shall be made to preclude the possibility of opening the cover in the case of excessive pressure or underpressure, as well as to preclude the possibility of pressurizing the receiver when the cover is partially closed.

6.3.5.2 The internal equipment, such as mixers, coils, disks, partitions, etc., hindering the internal inspection of the vessels shall be readily removable.

6.3.5.3 Sight glasses of not more than 150 mm in diameter, may be used to monitor the working spaces of mixers, provided that the working pressure in such spaces does not exceed 0.25 MPa.

6.3.5.4 In pressure vessels operating at a pressure exceeding 0.25 MPa, the covers of loading openings shall be so designed that, in the case of seal rupture, the hot medium escapes in a safe direction without hazard for the personnel.

6.3.5.5 Pressure vessels operating under vacuum conditions, heated by steam or water of a temperature over 115° C, shall be fitted with safety valves to prevent the pressure in the vacuum space from rising (due to the heating system leakage) higher than 0.85 times the test pressure.

These vessels shall be designed for such an opening pressure of the safety valve that the design stresses will not exceed 0.8 times the yield stress of the material at the design temperature.

6.3.5.6 For mixers heated by steam or water, as well as for the walls of vessels being in contact with the rotating product, the design wall thickness allowance, c , shall not be taken less than 2 mm.

6.4 Filters and Coolers

6.4.1 Filters and coolers of the main and auxiliary engines shall fulfil the requirements for heat exchangers and pressure vessels with respect to the materials and construction.

6.4.2 Oil fuel filters installed in parallel to enable their cleaning without cutting off the fuel oil supply to engines (duplex filters) shall be provided with arrangements protecting the filter under pressure against being opened inadvertently.

6.4.3 Filters or filter chambers shall be provided with adequate means for:

- air venting when being put into operation,
- pressure equalisation before being opened.

Valves or cocks with drain pipes leading to a safe location shall be used for this purpose.

Section 6 Gearing

1 Scope

1.1 The requirements of this Section cover the construction, material and inspection of reduction gears for main propelling purposes and for driving electric generators.

1.2 Design of bevel gears will be specially considered.

1.3 For torsional vibration requirements, See Sec.10.

1.4 Rated power of gear is the maximum transmitted power at which the gear is designed to operate continuously at its rated speed.

1.5 The rated torque is defined by the rated power and speed and is the torque used in the gear rating calculations.

1.6 The gear rating is the rating for which the gear is designed to transmit it's rated torque.

2 Plans and particulars

2.1 The following plans, in triplicate, of the reduction gearing are to be submitted:

For Approval

a) Pinion(s) and wheel(s);

b) Shafts;

c) Hub(s);

d) Other power transmitting parts;

For information only

e) Longitudinal and transverse sections of the gear box;

f) Clutch(es) and/or coupling(s);

g) Gear casing including propeller thrust bearing housing, if applicable.

2.2 The plans are to show clearly all dimensions, details of all fillets and stress raisers, and material of all the parts.

2.3 At least the following particulars of the gearing are to be submitted along with the plans:

a) Shaft power and revolutions for each pinion;

b) Number of teeth in each gear;

c) Generating pitch diameters;

d) Helix angles at generating pitch diameters;

e) Normal pitches of teeth at generating pitch diameters;

f) Tip diameters;

g) Root diameters;

h) Face widths and gaps, where applicable;

i) Pressure angles of teeth (normal or transverse) at generating pitch diameters;

j) Minimum backlash;

k) Centre distance;

l) Basic rack tooth form;

m) Details of tooth flank corrections, if adopted;

n) Details of post hobbing process, if any;

o) Case depth for surface-hardened teeth;

p) Shrinkage allowance for shrunk-on rims and hubs;

q) Type of coupling proposed for oil engine applications.

2.4 Gears with Multiple Prime Mover Inputs

2.4.1 For single helical gears with arrangements utilizing multiple prime mover inputs, and single or multiple outputs, the following analyses for all operating modes are to be conducted:

- All bearing reactions
- Tooth modifications
- Load distributions on the gear teeth
- Contact and tooth root bending stresses

A summary of the results of these analyses for each operating mode is to be submitted for review.

3 Materials

3.1 Specifications for materials of pinions, pinion sleeves, wheel rims, gear wheels and shafting giving chemical composition, heat treatment and mechanical properties are to be submitted for approval with the plans of gearing and are to be in accordance with Part.2.

3.2 Where the teeth of a pinion or gear wheel are to be surface hardened, the proposed specification and details of the procedure are to be submitted for approval.

3.3 In the selection of materials for pinions and wheels consideration should be given to their compatibility in operation. In general, for gears of through hardened steels, except in the case of low reduction ratios, provision should also be made for a hardness differential between pinion teeth and wheel teeth. For this purpose the specified minimum tensile strength of the wheel materials should not be more than 85 percent of that of the pinion.

3.4 Subject to 3.3, the specified minimum tensile strength of steel gear forgings is to be selected within the following limits:

- Pinions and pinion sleeves - 550-1050 [N/mm^2];
- Gear wheels and rims - 400-850 [N/mm^2].

A tensile strength range is also to be specified and is not to exceed 120 [N/mm^2] when the specified minimum tensile strength is 600 [N/mm^2] or less. For higher strength steels, the range is not to exceed 150 [N/mm^2].

3.5 Unless otherwise agreed, the specified minimum tensile strength of the core is to be 800 [N/mm^2] for induction-hardened or nitride gearing and 750 [N/mm^2] for carburized gearing.

4 Design and construction

4.1 The design and construction is to be such as to enable the gearing to meet the general requirements with respect to functional capability and reliability.

4.2 Detailed analysis to prove the design of the gearing is to be submitted for consideration.

In this regard, Classification Notes on the design of gearing may be followed.

4.3 Where castings are used for wheel centres, any radial slots in the periphery are to be fitted with permanent chocks before shrinking-on the rim.

4.4 Where bolts are used to secure side plates to rim and hub, the bolts should be tight fit with the holes and the nuts should be suitably locked by means other than welding.

4.5 When welding is employed in the construction of wheels, the welding procedure is to be approved by the Surveyors before work is commenced. For this purpose, welding procedure approval tests are to be carried out with satisfactory results. Such tests are to be representative of the joint configuration and materials. Wheels are to be stress relieved after welding. All welds are to have a satisfactory surface finish and contour. Magnetic particle or liquid penetrant examination of all important welding joints is to be carried out to the satisfaction of the Surveyors.

4.6 In general arrangements are to be made so that the interior structure of the wheel may be examined. Alternative proposals will be specially considered.

5 Accuracy of gear cutting and alignment

5.1 Gears are to be cut only on machines which are maintained at a high standard of accuracy. Hobbing machines used in the production of large gears are to be operated under conditions of temperature control with a total temperature variations not exceeding 2°C for the finishing cut. The blank should be allowed sufficient time to stabilize to the machine temperature before cutting commences.

5.2 The accuracy of gear-cutting of pinions and wheels is to be demonstrated to the satisfaction of the Surveyors. For this purpose, records of measurements of pitch error, undulations, axial pitch errors, tooth thickness and backlash should be available for review by Surveyors on request.

5.3 The alignment is to be demonstrated in the workshop by meshing in the gearbox without oil clearance in the bearings, or in the meshing frame without oil clearance in the bearings or on rollers. Meshing is to be carried out with the gears locating in their load positions, and a load sufficient to overcome pinion weight and axial movement is to be imposed.

5.4 A permanent record is to be made of the meshing contact for the purpose of re-checking the alignment when installed on board ship. The meshing contact on each helix is not to be less than following:

a) For through-hardened gears,

- 40 percent of the working depth for 35 percent of the length; and
- 20 percent of the working depth for further 35 percent of the length;

b) For through-hardened gears and for all surface hardened gears,

- 40 percent of the working depth for 50 percent of length; and
- 20 percent of the working depth for a further 40 percent of the length.

6 Balancing of gear pinions and wheels

6.1 All pinions, gear wheels and flexible couplings or sleeves whose maximum designed speed of rotation exceeds 1000 revolutions per minute are to be dynamically balanced, where the speed of rotation is 1000 revolutions per minute or less, these components are to be statically or, alternatively, dynamically balanced.

Parts of couplings, etc., which are to be fixed to the gear in service are normally to be attached before balancing.

6.2 For static balancing the final out of balance of each assembly at the balancing planes is not to exceed 2200 [N mm/tonne] of gears whose maximum design speed is less than 300 revolutions per minute and 680 [N mm/tonnes] for gears whose maximum design speed is between 300 and 1000 revolutions per minute.

For dynamic balancing the final out of balance is not to exceed 190,000/N_1 [N mm/tonne], where

N_1 = revolutions per minute appropriate to the assembly.

6.3 Balancing may, however, be omitted for turbine secondary pinions and for oil engines gearing, provided that the rotating components are of solid forged construction or have a solid forged centre with shrunk-on rim and in both cases are machined to give a concentric and uniform cross-section.

7 Gearcases

7.1 Gearcases and their supports are to be designed sufficiently stiff such that misalignment at the mesh due to movements of the external foundations and the thermal effects under all conditions of service do not disturb the overall tooth contact. If welding is employed in their construction they are to be stress-relieved on completion.

7.2 Inspection openings should be provided at the peripherals of gearcases to enable the teeth of pinions and wheels to be readily examined.

When the construction of gearcases is such that sections of the structure cannot readily be moved for inspection purposes, access openings of adequate size are to be also provided at the ends of the gearcases to permit examination of the structure of the wheels. Their attachment to the shafts should be capable of being examined by removal of bearing caps or by equivalent means.

8 Type tests and sea trials

8.1 Upon completion of fabrication and assembly, reduction gear unit is to be subjected to type testing in accordance with the agreed test programme which is to be submitted by the manufacturer for approval. Type tests are to be witnessed by the Surveyor.

8.2 Reduction gearing units, in general, are to be type tested at maker’s works and test load and duration of testing is to be agreed upon in each case.

8.3 Tests are to include demonstration of satisfactory operation of clutches and couplings, if fitted.

8.4 After completion of type tests, all gear elements are to be examined for tooth contact marking and alignment. All gear tooth contact is to conform to the requirements.

8.5 The gear lub.oil system is to be provided with means of indicating the lub.oil pressure supply to them. Alarms are to be provided to indicate low lub.oil pressure, low clutch oil/air pressure and high lub.oil temperature.

9 Alignment and weardown gauges

9.1 Reduction gears with sleeve bearings for main and auxiliary turbines and oil engines, are to be provided with weardown gauges or micrometers for testing the internal alignment of the various elements in the gearcases. In certain gears, e.g. gears of the dual tandem type, the direction of loading on the bearings of a gear element may be such that an accurate indication of its alignment under operating conditions cannot be obtained using weardown gauges. In these instances, suitable alternatives such as crown thickness micrometer are to be provided.

9.2 Approved means are to be provided by the gear manufacturer to enable the Surveyors to verify that no distortion of the gearcase has taken place, when chocked and secured to its seating on board ship.

10 Trials

10.1 The sea trials should be of sufficient duration to prove the gears. After these trials, the marking revealed by inspection should indicate freedom from hard bearings, particularly towards both ends of each helix.

10.2 In the case of through-hardened gears, not less than 70 percent contact across effective face width should be indicated. When the teeth of such gears are finished by an approved post hobbing process or profile ground, not less than 90 percent contact across the effective face width is to be indicated.

10.3 For surface hardened gears, the contact across the effective face width is also to be not less than 90 percent.

Section 7 Main Propulsion Shafting

1 Scope

1.1 The requirements of this Section apply to shafting for main propulsion of straight forged design and which are driven by rotating machines such as diesel engines, turbines or electric motors. The requirements for couplings, coupling bolts, keys, keyways, sternbushes and associated components are also included. The diameter of shafting as calculated may require to be modified as a result of alignment considerations and vibration characteristics (See Sec.10) or the inclusion of stress raisers, other than those contained in this section.

The requirements given in this section do not cover shafts intended for following application.

- gearing shafts
- electric motor shafts
- generator rotor shafts
- turbine rotor shafts.

1.2 The scantlings of shafts that are integral to equipment, such as for gear boxes, podded drives, electrical motors and/or generators, thrusters, turbines and which in general incorporate particular design features are to be determined taking into account appropriate additional criteria including that for stiffness, high temperature application etc. The requirements given in this section may be applied if such shafts are subjected mainly to torsion and are having traditional design features.

2 Alternative calculation methods

2.1 Alternative calculation methods will be considered provided these calculations take into account all relevant loads in the complete dynamic shafting system under all permissible operating conditions giving due consideration to the dimensions and arrangements of all shafting connections. The alternative calculation method is to also take into account design criteria for continuous and transient operating loads for dimensional adequacy for fatigue strength and peak operating loads for yield strength. Refer 2.2 to 2.5 as guidance for alternative calculations.

2.2 The two important considerations that are essential for the design of propulsion shafting are:

a) Fatigue

b) Stress concentration and notch sensitivity.

Fatigue: The deterioration of the properties of material which takes place under conditions involving fluctuating stresses. Fatigue failures generally occur at loads, which if applied statically would be below the elastic limit. The fatigue limit of a material is the stress which will not produce failure, even if many fluctuations of it are imposed.

Stress concentration in shafts: Basic stress analysis calculations assume that the components are smooth, have a uniform section and have no irregularities. In practice virtually all engineering components have to have changes in section and/or shape. Common examples are shoulders on shafts, oil holes, key ways and screw threads. Any discontinuity changes the stress distribution in the vicinity of the discontinuity, so that the basic stress analysis quations no longer apply. Such 'discontinuities' or 'stress raisers' cause local increase of stress referred to as 'stress concentration'.

For static loading the theoretical or geometric stress concentration factors K_t or K_{ts} relate to actual maximum stress at the discontinuity to the nominal stress as follows:

K_t = maximum direct stress/nominal direct stress

K_{ts} = maximum shear stress/nominal shear stress.

The subscript 't' denotes that the stress concentration value is a theoretical calculation based only on the geometry of the component and discontinuity.

Some materials are not as sensitive to notches as implied by the theoretical stress concentration factor. For these materials a reduced value of stress concentration factor K_f may be used where the maximum stress = K_f x nominal stress. The value of K_f which depends on notch sensitivity 'q' is to be determined using the following equation:

$q = (K_f - 1) / (K_t - 1)$ where q is between 0 and 1.

If q = 0, then $K_f = 1$ as the material has no sensitivity to notches. If q = 1, then $K_f = K_t$ and the material is fully notch sensitive.

When designing, usual practice is to first find K_t from the geometry of the component, then specify the material and determine the notch sensitivity, q from the chart for the notch radius.

For cyclic loading, the theoretical stress concentration factor is to be defined as

K_{t1} = (endurance limit with stress concentration /endurance limit without stress concentration)

Using the notch sensitivity factor 'q' in cyclic loading of shaft, fatigue stress concentration factor K_f is calculated as:

$K_f = 1 + q\ (K_{t1} - 1)$

2.3 The alternative calculation methods are to take into account following fatigue related issues as have been considered in rule formulations:

a) Low cycle fatigue criterion (typically < 10^4), i.e. the primary cycles represented by zero to full load and back to zero, including reversing torque if applicable.

b) High cycle fatigue criterion (typically > 10^7), i.e. torsional vibration stresses permitted for continuous operation as well as reverse bending stresses.

The limits for torsional vibration stresses are given in sec 10.

c) The accumulated fatigue due to torsional vibration when passing through a barred speed range or any other transient condition with associated stresses beyond those permitted for continuous operation is addressed by the criterion for transient stresses in sec10.

2.4 The factors k (for low cycle fatigue) and C_k (for high cycle fatigue) as given in Table 2.1 and Table 4.2 of sec. 10, respectively take into account the influence of:

- The stress concentration factors (scf) relative to the stress concentration for a flange with fillet radius of 0.08do (geometric stress concentration of approximately 1.45).

$$c_k \approx 1.45/scf \text{ and } k \approx [scf/1.45]^x$$

where the exponent x considers low cycle notch sensitivity.

- The chosen values of the notch sensitivity are mainly representative for soft steels (σB < 600), while the influence of steep stress gradient s in combination with high strength steels may be underestimated.
- The size factor CD being a function of diameter only does not purely represent a statistical size influence, but rather a combination of this statistical influence and the notch sensitivity.

2.5 The stress concentration factor (scf) at the end of slots can be determined by means of the following empirical formulae:

$$scf = \alpha_{t(hole)} + 0.57 \frac{(l-e)/d}{\sqrt{(1-d_i/d)e/d}}$$

where,

e = slot width

l = length of the slot

d_o = outer diameter

d_i = inner diameter (Refer figure given under Table 2.1).

This formula applies to:

- slots at 120 or 180 or 360 degrees apart.
- slots with semicircular ends. (Though multiradii slot end can reduce the local stresses, this is not included in this empirical formula).
- slots with no edge rounding (except chamfering), as any edge rounding increases the scf slightly.

$\alpha_{t(hole)}$ = factor representing the stress concentration of radial hole of diameter e:

$$= 2.3 - 3e/d + 15(e/d)^2 + 10(e/d)^2(d_i/d)^2$$

Table 2.1: Shaft design factors k for line shafts and thrust shafts

Factor	Intermediate shaft with					Thrust shafts external to engine		
	Integral coupling flange [1)]	Shrink fit coupling[2)]	Key-ways cylindrical and tapered [3),4)]	Radial holes, transverse holes [5)]	Longitudinal slots[6)]	On both sides of thrust collars [1)]	In way of axial bearings where a roller bearing is used for taking up thrust	Straight sections
k	1.0	1.0	1.1	1.1	1.2	1.1	1.1	1.0

Notes:

1) Fillet radius is not to be less than 0.08d.

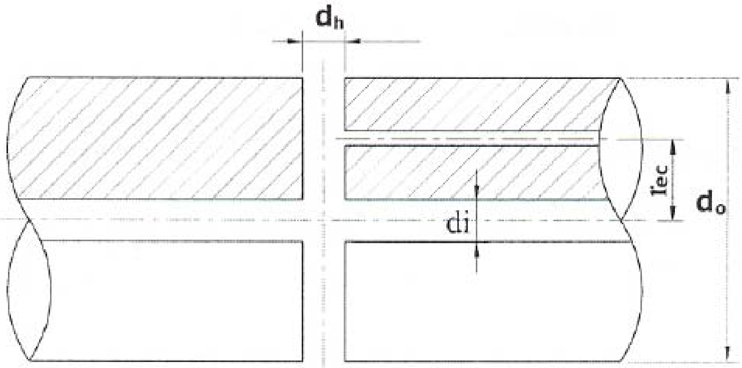
2) k refers to the plain shaft section only. Where shafts may experience vibratory stresses close to the permissible stresses for continuous operation, an increase in diameter to the shrink fit diameter is to be provided, e.g. a diameter increase of 1 to 2% and a blending radius nearly equal to the change in diameter are to be provided.

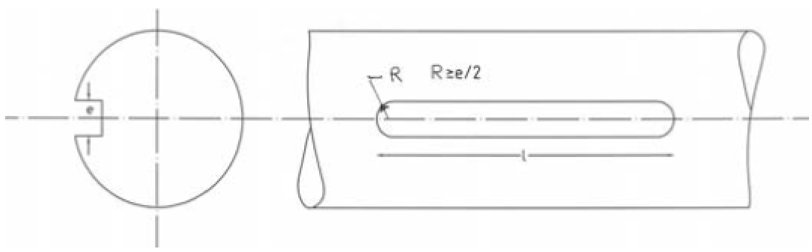
3) At a distance of not less than 0.2d from the end of the keyway the shaft diameter may be reduced to the diameter calculated with k = 1.0. Fillet radii in the transverse section of the bottom of the key way are not to be less than 0.0125d.

4) It is recommended that keyways are in general not to be used in installations with a slow speed crosshead or 2-stroke engines with a barred speed range.

5) Diameter of radial bore (dh) not to exceed 0.3do.

The intersection between a radial and an eccentric (rec) axial bore (see below) the value will be determined on the basis of data submitted in each case.





6) Subject to following limitations being complied with -

i) slot length (I)/outside diameter < 0.8 and

ii) inner diameter (di)/outside diameter do < 0.8 and

iii) slot width (e)/outside diameter do > 0.10.

The end rounding of the slot is not to be less than e/2. An edge rounding should preferably be avoided as this increases the stress concentration slightly. The k value is valid for 1, 2 and 3 slots and they are to be arranged 360, 180 or 120 degrees apart from each other respectively.

3 Plans and particulars

3.1 The following plans, in triplicate, together with the necessary particulars of the machinery, including the maximum power and revolutions per minute, are to be submitted for approval before the work is commenced.

- Power take-off arrangement if any (e.g. shaft generator), propulsion boosters or similar equipment rated for 100 [kW] and above;
- Final gear shaft;
- Thrust shaft;
- Intermediate shafting, shaft bearings;
- Tube shaft, where applicable;
- Tail shaft;
- Stern tube, shaft seals and Stern bush;
- Stern tube lubrication system;
- Couplings (integral, demountable, keyed or shrink-fit), coupling bolts and keys;
- Flexible coupling including constructional details, static and dynamic torsional stiffness, damping characteristic, rated power, torque and RPM, allowable vibratory torque for continuous and transient operation and allowable misalignment for continuous operations;
- Cardan shafts, if fitted.

3.2 The specified minimum tensile strength of each shaft is to be stated.

3.3 A shafting arrangement plan indicating the relative position of the main engines, flywheel, flexible coupling, gearing, thrust block, line shafting and bearings, stern tube, 'A' brackets and propeller, as applicable, is to be submitted for information.

4 Materials for shafting

4.1 The materials are to comply with the relevant requirements of Pt. 2. The specified minimum tensile strength of forgings is to be selected within the following general limits:

a) Carbon and carbon-manganese steel 500- 600 [N/mm^2]; However, shaft material having specified minimum tensile strength of 400 [N/mm^2] may be used if calculations are submitted to show that vibratory stresses occurring in the shafts are lower than the permissible stresses even in the transient operation.

b) Alloy steels - 500-800 [N/mm^2].

4.2 If materials with greater specified or actual tensile strength than the limitations given in 4.1 are used, no consideration will be given for reduction of shaft diameter or acceptance of higher permissible vibratory stresses, than those stated in 4 to 6.

4.3 Ultrasonic tests are required on shaft forgings where the diameter is 250 [mm] or greater.

5 Intermediate and thrust shafts

5.1 The diameter, d, of the shaft is to be not less than determined by the following formula:

$$d = Fk\sqrt[3]{\frac{P}{n}\left(\frac{560}{\sigma B+160}\right)} \qquad [\text{mm}]$$

where,

F = 95 for turbine installations, electric propulsion installations and oil engine installations with slip type couplings;

= 100 for other oil engine installations;

k = shaft design factors as given in Table 2.1;

σB = specified minimum tensile strength of the material [N/mm^2]. For calculation purposes, this value is not be taken greater than 800 [N/mm^2];

P = maximum shaft power, in [kW];

n = Revolutions per minutes corresponding to maximum shaft power giving maximum torque.

5.2 For shafts with design features other than stated in Table 2.1, the value of k will be specially considered.

6 Tailshafts and stern tube shafts

6.1 The diameter, dp, of the tailshaft immediately forward of the forward face of the propeller boss or, if applicable, the forward face of the tailshaft flange, is to be not less than determined by the following formula:

$$d = 100k\sqrt[3]{\frac{P}{n}\left(\frac{560}{\sigma B+160}\right)} \ [\text{mm}]$$

where,

k = shaft design factors as given in Table 6.1;

σB = specified minimum tensile strength of the material [N/mm^2]. For calculation purposes, this value is not to be taken greater than 600 [N/mm^2];

P and n are defined in 5.

6.2 The diameter, d_p of the tailshaft determined in accordance with the formula in 6.1 is to extend over a length not less than that to the forward edge of the bearing immediately forward of the propeller or 2.5 dp whichever is the greater.

6.3 The diameter of the portion of the tailshaft and tubeshaft forward of the length required by 6.2 to the forward end of the forward stern tube seal is to be determined in accordance with the formula in 6.1 except that:

Table 6.1: Shaft design factors k for tailshafts 1) and stern tube shafts

Factor	Propulsion Drive	Stern tube configuration	Tailshafts : propeller attachment method			Stern tube shafts
			Keyed	Key less attachment by shrink fit	Flanged	
k	All	Oil lubricating bearings and provided with an approved type of oil seating gland	1.26	1.22	1.22	1.15
	All	All Water lubricated bearings : continuous shaft liners or equivalent	1.26	1.22	1.22	1.15
	All	All Water lubricated bearings : non-continuous shaft liners	1,29	1.25	1.25	1.18

Note: 1) Fillet radii in the transverse section at the bottom of the keyway are not to be less than $0.0125d_p$

k = 1.15, where k = 1.22 or 1.26 as required by 6.1 (shafts fitted with continuous liner or oil lubricated);

k = 1.18, where k = 1.25 or 1.29 as required by 5.1 (shafts with water lubricated bearings).

The change of diameter from that required by 6.1 to that required by this clause should be gradual.

6.4 Tailshafts which run in sterntubes and tube shafts may have the diameter forward of the forward stern tube seal gradually reduced to the diameter of the intermediate shaft. Abrupt changes in shaft section at the tailshaft/ tubeshaft to intermediate shaft couplings are to be avoided.

7 Hollow shafts

7.1 For hollow shafts where the bore exceeds 40 percent of the outside diameter the minimum shaft diameter is not to be less than that given by the following equation:

$$d_o = d\sqrt[3]{\frac{1}{1-(d_i/d_o)^4}} \quad \text{[mm]}$$

where,

d_o = outside diameter [mm];

d = Rule size diameter of shaft [mm], calculated in accordance with 5 or 6;

d_i = diameter of central hole [mm].

7.2 Where the diameter of central hole does not exceed 0.4 times the outside diameter, no increase over Rule size need be provided.

8 Integral couplings

8.1 The thickness of coupling flanges is not to be less than the minimum required diameter of the coupling bolts calculated as in sub-section 9, with tensile strength of the bolt material being taken as the tensile strength of the corresponding shaft material or 0.2 times the rule diameter of the shaft under consideration, whichever is greater. Special consideration will be given by ACS for flanges having non-parallel faces;

However, in such cases the thickness of the flanges is not be less than the coupling bolt diameter.

8.2 The fillet radius at the base of the coupling flange is to be not less than 0.08 of the diameter of the shaft at the coupling. The fillets are to have a smooth finish and are not to be recessed in way of nuts and bolt heads. The fillet may be formed of multiradii in such a way that the stress concentration factor will not be greater than for a circular fillet with radius 0.08 times the actual shaft diameter.

8.3 Where the propeller is attached by means of a flange, the thickness of the flange is to be not less than 0.25 times the actual diameter of the adjacent part of the tailshaft. The fillet radius at the base of the coupling flange is to be not less than 0.125 times the diameter of the shaft at the coupling.

9 Demountable couplings

9.1 Couplings are to be made of steel or other approved ductile material. The strength of demountable couplings and keys is to be equivalent to that of the shaft. Couplings are to be accurately fitted to the shaft.

9.2 Hydraulic and other shrink fit couplings will be specially considered upon submittal of detailed preloading and stress calculations and fitting instructions. In general, the torsional holding capacity is to be at least 2.8 times the transmitted torque and preload stress is not to exceed 70 percent of the yield strength.

9.3 Provision is to be made to resist astern pull.

10 Tooth couplings

10.1 The contact stress, σ_c, at the flanks of mating teeth of a gear coupling is not to exceed that given in Table below, where:

$$\sigma_c = \frac{24 \times 10^6 P}{n d_p b h z} \qquad [\mathrm{N/mm^2}]$$

P and n are defined in 5.1.

d_p = pitch circle diameter of coupling teeth [mm]

b = tooth face width [mm]

h = tooth height [mm]

z = number of teeth (per coupling half).

Allowable σ_c values

Tooth material Surface treatment	Allowable σ_c value [N/mm^2]
Surface hardened teeth	19
Through hardened teeth	11

10.2 Where experience has shown that under similar operating and alignment conditions, a higher tooth loading can be accommodated full details are to be submitted for consideration.

11 Flexible couplings

11.1 Details of flexible couplings are to be submitted together with the manufacturers' rating capacity, for the designed operating conditions including short term high power operation. Verification of coupling characteristics will be required.

11.2 In determining the allowable mean, maximum and vibratory torque ratings, consideration of the mechanical properties of the selected elastic element type in compression, shear and fatigue loading together with heat absorption/generation is to be given.

11.3 In determining the allowable torque ratings of the steel spring couplings, consideration of the material mechanical properties to withstand fatigue loading and overheating is to be given.

12 Interference fit assemblies

12.1 The interference fit assembly is to have a capacity to transmit a torque Q without slippage.

$Q = 9550\ P\ (1+C)\ S/n$ [N-m]

Where,

P = power transmitted, kW

n = RPM of the shaft

C = coefficient as per Table 12.1

S = 2.0 for assemblies accessible from within the vessel

= 2.5 for assemblies not accessible from within the vessel.

Table 12.1: 'C' values for guidance purposes

Coupling Location	C
High Speed Shafting - IC engine driven	0.3
High Speed Shafting - Electric Motor or Turbine driven	0.1
Low Speed Shafting - Main or PTO stage gearing	0.1

12.2 The effect of any axial load acting on the assembly is to be considered.

12.3 The resulting equivalent von Mises stress in the assembly is not to be greater than the yield strength of the component material.

12.4 Reference marks are to be provided on the adjacent surfaces of parts secured by shrinkage alone.

13 Coupling bolts

13.1 The diameter of the fitted bolts at the joining faces of the coupling is to be not less than that given by the following formula:

$$d_b = 0.65\sqrt{\frac{d^3(T+160)}{iDT_b}}$$

where,

d_b = diameter of the fitted coupling bolts [mm];

d = required diameter [mm], of the intermediate shaft taking into account ice strengthening requirements, if applicable;

T = specified minimum tensile strength of the shaft material [N/mm^2];

T_b = specified minimum tensile strength of the bolt material [N/mm^2];

= and also $T \le T_b \le 1.7$ T, but not higher than 1000 [N/mm^2]

i = number of bolts in the coupling;

D = pitch circle diameter of bolt holes [mm].

13.2 The diameter of the non-fitted bolts will be specially considered upon the submittal of detailed preloading and stress calculations and fitting instructions.

14 Tailshaft liners

14.1 The thickness, t, of bronze or gunmetal liners fitted on tailshafts, in way of bearings, is not to be less than given by following formula:

$T=(168+d_p)/28$ [mm]

where,

t = thickness of liner [mm];

d_p = diameter of tailshaft under the liner [mm].

14.2 The thickness of the continuous liner between the bearings is not be less than 0.75t.

14.3 Continuous liners are preferably to be cast in one length. If made of several lengths, the joining of the separate pieces is to be made by welding through the whole thickness of liner before shrinking. In general, the lead content of the gunmetal of each length forming a butt welded liner is not to exceed 0.5 percent. The composition of the electrode or filler rods is to be substantially lead free.

14.4 The liners are to withstand a hydraulic pressure of 2.0 bar after rough machining.

14.5 The liners are to be carefully shrunk or forced upon the shaft by hydraulic pressure, and they are not to be secured by pins.

14.6 Effective means are to be provided for preventing water from reaching the shaft at the part between the after end of the liner and the propeller boss.

14.7 If the liner does not fit the shaft tightly between the bearing portions in the stern tube, the space between the shaft and the liner is to be filled with a plastic insoluble non-corrosive compound.

15 Keys and keyways for propeller connections

15.1 Round ended or sled-runner ended keys are to be used, and the key ways in the propeller boss and cone of the tailshaft 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 tailshaft at the top of the cone. The sharp edges at the top of the keyways are to be removed.

15.2 Two screwed pins are to be provided for securing the key in the keyway, and the forward pin is to be placed at least one-third of the length of the key from the end. The depth of the tapped holes for the screwed pins is not to exceed the pin diameter and the edges of the holes are to be slightly beveled.

15.3 The distance between the top of the cone and the forward end of the keyway is to be not less than 0.2 of the diameter of the tailshaft at the top of the cone.

15.4 The effective sectional area of the key in shear, is to be not less than $d^3/(2.6\ d_1)$ [mm^2]

where,

d = diameter [mm], required for the intermediate shaft determined in accordance with 6.4, based on material having a specified minimum tensile strength of 400 [N/mm^2];

d_1 = diameter of shaft at mid-length of the key [mm].

16 Stern tube and bearings

16.1 The length of the bearing in the sternbush next to and supporting the propeller is to be as follows:

a) For water lubricated bearings which are lined with lignum vitae, rubber composition or staves of approved plastic material; the length is to be not less than 4 times the diameter required for the tailshaft under the liner;

b) For bearings which are white-metal lined, oil lubricated and provided with an approved type of oil sealing gland; the length of the bearing is to be approximately twice the diameter required for the tailshaft and is to be such that the nominal bearing pressure will not exceed 0.8 [N/mm^2]. The length of the bearing is to be not less than 1.5 times its diameter;

c) For bearings of cast iron, bronze which are oil lubricated and fitted with an approved oil sealing gland; the length of the bearing is, in general, to be not less than 4 times the diameter required for tailshaft;

d) For bearings which are grease lubricated, the length of bearing is to be not less than 4 times the diameter required for the tailshaft;

e) For water lubricated bearings lined with two or more circumferentially spaced sectors of an approved plastics material, in which it can be shown that the sectors operate on hydrodynamic principles, the length of the bearing is to be such that the nominal bearing pressure will not exceed 0.55 [N/mm^2]. The length of the bearing is not to be less than twice its diameter;

f) For approved oil lubricated bearings of synthetic rubber, reinforced resin or plastic materials, the length of the bearing is to be not less than 2.0 times the rule diameter of the shaft in way of the bearing. The length of the bearing may be reduced provided the nominal pressure is not more than 6 bar as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing divided by the projected area of the shaft. In any case the length is not to be less than 1.5 times the actual diameter. Where the material has proven satisfactory testing and operating experience, consideration may be given to an increased bearing pressure.

16.2 Forced water lubrication is to be provided for all bearings lined with rubber or plastics and for those bearings lined with lignum vitae where the shaft diameter is 380 [mm] or over. The supply water may come from a circulating pump or other pressure source. The water grooves in the bearings are to be of ample section and of a shape which will be little affected by weardown, particularly for bearings of the plastic type.

16.3 The shut off valve or cock controlling the supply of water is to be fitted direct to the after peak bulkhead, or to the sterntube where the water supply enters the sterntube forward of the bulkhead.

16.4 Where a tank supplying lubricating oil to the sterntube is fitted, it is to be located above the load water line and is to be provided with a low level alarm device in the engine room.

16.5 Where sternbush bearings are oil lubricated, provision is to be made for cooling the oil by maintaining water in the after peak tank above the level of the sterntube or by other approved means. Means of ascertaining the temperature of the oil in the sternbush are also to be provided.

For vessels with tailshaft condition monitoring (MON-SHAFT) notation, at least two independent temperature sensors or other approved arrangements are to be provided for measuring the aft bearing temperature.

16.6 The oil sealing glands used for sterntube bearings, which are oil lubricated, are to be of approved type.

16.7 An arrangement for readily obtaining accurate oil samples is to be provided. The sampling point is to be taken from the lowest point in the lub.oil system as far as practicable. Also the arrangements are to be such as to permit the effective removal of the contaminants from the oil lubricating system.

16.8 Stern seals are to be of the axially direct face type. Soft packing glands are to be used only if specified by Owners.

16.9 Where bulkhead glands are fitted, a watertight sealing arrangement is to be provided. Bulkhead seals is not to be formed by a bulkhead mounted plummer bearing.

16.10 Plummer bearings are to be either bulkhead mounted or of pedestal type.

17 Roller element bearings

17.1 Roller element bearings are to have design life, L_{10h} not less than:

- 40,000 hours for propeller thrust bearing;

- 30,000 hours for other bearings.

Where L_{10h} is the basic rating life in hours which 90% of a sufficiently large group of apparently identical bearings is expected to attain.

18 Shaft bearing materials

18.1 Shaft bearing fitted in stern bushes and shaft bossings in “A” and “P” brackets are to be constructed from an approved material and effectively secured to prevent rotational and axial movement in the stern tube(s) and stern bush(es)

19 Glass Reinforced Plastic coating

19.1 The tail shaft may be protected by a fiberglass reinforced plastic coating between liners in accordance with the following procedure, which effectively prevents sea water from contacting the steel shaft. In such cases, the tailshaft survey interval would be 5 years as applicable for the tailshaft survey notation. The procedure is to be approved in each case:

a) Coatings are to consist of at least 4 plies of cross-woven glass tape impregnated with resin or equivalent process.

b) The shaft is to be cleaned with solvent or grit blasted.

c) Shaft is to be examined and 1st coat is to be given in presence of Surveyors.

d) Shaft is to be subjected to spark test after coating. There should be freedom from porosity.

e) Effective means are to be provided to prevent water gaining access to the metallic region of the shaft.

f) It is to be ensured that provision is made for overlapping and adequate bonding of the coating.

g) The end of the liner is to stepped and tapered as required to protect the end of the wrapping.

Section 8 Propellers

1 Scope

1.1 The requirements of this Section cover the construction, materials and inspection of propellers.

2 Plans and particulars

2.1 A plan, in triplicate, of the propeller is to be submitted for approval, together with the following particulars:

a) Maximum shaft power, P, in [kW];

b) Revolutions per minute of the propeller at maximum power, R;

c) Propeller diameter, D [m];

d) Pitch at 25 percent radius (for solid propellers only), $P_{0.25}$ [m];

e) Pitch at 35 percent radius (for controllable pitch propellers only), $P_{0.35}$ [m];

f) Pitch at 70 percent radius, $P_{0.7}$ [m];

g) Length of blade section of the expanded cylindrical section at 25 percent radius (for solid propeller only), $L_{0.25}$ [mm];

h) Length of blade section of expanded cylindrical section at 35 percent radius (for controllable pitch propellers only) $L_{0.35}$ [mm];

i) Rake at blade tip measured at shaft axis (backward rake positive, forward rake negative), K [mm];

j) Number of blades, N;

k) Developed area ratio, a.

2.2 In case of controllable pitch propeller following additional plans / data is to be submitted:

- Hub and it’s attachments to tailshaft flange with connecting bolts
- Propeller blade flange and it’s attachment bolts
- Internal control mechanisms
- Hydraulic piping control systems
- Instrumentation and alarm systems
- Strength calculations for internal components

In case of highly skewed propellers with skew angle greater than 50 degree and controllable pitch propeller skew angle greater than 25 degrees, propeller load and stress analysis proving adequacy of blade strength are to be submitted.

3 Materials

3.1 Castings for propellers and propeller blades are to comply with the requirement of Part 2, Ch. 4 and 8. The specified minimum tensile strength is to be not less than stated in Table 3.1.

3.2 When it is proposed to use materials which are not included in Table 3.1, details of the chemical composition, mechanical properties and density are to be submitted for approval.

Table 3.1: Material constants

Materials	Specified min. UTS [N/mm^2]	f	w
Manganese bronze Grade Cu 1	440	20.6	8.3
Ni-Manganese bronze Grade Cu 2	440	20.9	8.0
Ni-Aluminium bronze Grade Cu 3	590	25.7	7.5
Mn-Aluminium bronze Grade Cu 4	630	23.25	7.5
Cast iron	250	11.77	7.2
Carbon and low alloy steels	400	14.0	7.9

Note: The value of f may be increased by 10 percent for twin screw and outboard propellers of triple screw ships.

4 Design

4.1 Minimum blade thickness

4.1.1 Where the propeller blades are of conventional design, the thickness, t, of the propeller blades at 25 percent radius for solid propellers, at 35 percent for controllable pitch propellers, neglecting any increase due to fillets, is to be not less than:

a) For fixed propellers

$$t_{0.25} = 1055\sqrt{\frac{AP}{C_n CRN} + \frac{2.5BKC_s}{CC_n}}$$

b) For controllable pitch propellers

$$t_{0.35} = 847\sqrt{\frac{AP}{C_n CRN} + \frac{1.6BKC_s}{CC_n}}$$

where,

$t_{0.25}$ = minimum blade thickness required at 25 percent radius;

$t_{0.35}$ = minimum blade thickness required at 35 per radius;

C_n = section modulus coefficient at 25 percent radius or 35 percent radius as applicable;

= $l_0 / U_f LT^2$ and is not to be taken greater than 0.10;

l_o = moment of inertia of the expanded cylindrical section at 25 percent radius or 35 percent radius, as applicable, about a straight line passing through the center of gravity parallel to the pitch line or to the nose-tail line [mm^4];

U_f = maximum normal distance from the moment of inertia axis to points on the face boundary (tension side) of the section at 25 percent radius or 35 percent radius, as applicable [mm];

L = length of the blade section of the expanded cylindrical section at 25 percent radius or 35 percent radius, as applicable [mm];

T = maximum thickness of the expanded cylindrical section as approved at 25 percent or 35 percent radius, as applicable [mm];

C_s = section area coefficient at 25 percent radius or 35 percent radius as applicable;

$=a_s/LT$

a_s = area of the expanded cylindrical section at 25 percent radius or 35 percent radius, as applicable [mm^2];

f = material constant as per Table 3.1;

w = material constant as per Table 3.1;

a) For fixed-pitch propellers

$$A = 1.0 + \frac{6.0D}{P_{0.7}} + \frac{4.3P_{0.25}}{D};$$

$$B = \left(\frac{4300wa}{N}\right)\left(\frac{R}{100}\right)^2\left(\frac{D}{20}\right)^3;$$

$$C = \left(1 + \frac{1.5P_{0.25}}{D}\right)\left(L_{0.25}f - B\right)$$

b) For controllable pitch propellers

$$A = 1.0 + \frac{6.0D}{P_{0.7}} + \frac{3.0P_{0.35}}{D};$$

$$B = \left(\frac{4900wa}{N}\right)\left(\frac{R}{100}\right)^2\left(\frac{D}{20}\right)^3;$$

$$C = \left(1 + \frac{0.6P_{0.25}}{D}\right)\left(L_{0.35}f - B\right)$$

4.1.2 Propellers of unusual design or application will be subject to special consideration upon submittal of detailed stress calculations.

4.1.3 Fillets at the root of the blades are not to be considered in the determination of blade thickness.

4.2 Keyless propellers

4.2.1 Where propellers are fitted without keys, detailed stress calculations and fitting instructions are to be submitted for approval.

4.3 Controllable pitch propellers

4.3.1 In the case of controllable – pitch propellers, means are to be provided to lock the blades in ahead position in case of the failure of the pitch operating mechanism.

4.3.2 A propeller pitch indicator is to be fitted at each location from which it is possible to control the pitch of the propeller.

5 Fitting of propellers

5.1 The propeller boss is to be a good fit on the tailshaft cone. The forward edge of the bore of the propeller boss is to be rounded to about 6 [mm] radius. In general the contact area between propeller hub and tailshaft taper is to be not less than 70 percent of the theoretical contact area. On completion of final pull-up propeller is to be secured.

5.2 The exposed part of the tailshaft is to be protected from the action of water by filling all spaces between propeller hub, cap and shaft with a suitable filling material. The propeller assembly is to be sealed at the forward end with a well-fitted soft rubber packing ring. When the rubber ring is fitted in an external gland, the hub counterbore is to be filled with suitable material, and clearances between shaft liner and hub counterbore are to be kept to a minimum. When the rubber ring is fitted internally, ample clearance is to be provided between liner and hub and the ring is to be sufficiently sized to squeeze in to the clearance space when the propeller is driven up on the shaft, and, where necessary, a filler piece is to be fitted in the propeller - hub keyway to provide a flat unbroken seating for the ring. The recess formed at the small end of the taper by the over hanging propeller hub is to be packed with red lead putty or rust-preventing compound before the propeller nut is put on.

5.3 Effective means are to be provided to prevent the slackening of the propeller nut.

Section 9 Thrusters

1 Scope

1.1 The requirements of this section are applicable to:

- fixed thruster for propulsion
- steerable thruster units (azimuth thrusters) for propulsion and steering
- tunnel thruster for transverse propulsion aid to maneuvering.

2 Plans and particulars

The following plans and information in triplicate are to be submitted.

2.1 Fixed/azimuth propulsion thrusters

a) A general arrangement sectional assembly plan showing all the connections of the torque transmitting components from the prime mover to the propeller, together with the azimuthing mechanism and if a nozzle is provided, the nozzle ring structure and nozzle support struts.

b) Detailed and dimensional plans of the individual torque transmitting components.

c) Schematic plans for lubricating and hydraulic systems, together with pipe material, relief valves and working pressures.

2.2 Tunnel thrusters In addition to applicable requirements of 2.1, structural assembly plan including connections to tunnel.

2.3 Calculations and specifications

a) Thruster prime mover type and operational power/speed envelop.

b) Rating and type of motor for the azimuthing mechanism (e.g. type hydraulic or electric).

c) Gearing calculations for the azimuthing and propulsion mechanism which is to be designed in accordance with classification notes on the design of gearing. Calculation for bevel gears is to be on the basis of a conversion to equivalent helical gear.

d) Bearing specifications.

e) Calculations indicating suitability of components for short term high power operation, where applicable.

f) Where design is carried out using fatigue analysis, a fatigue strength analysis of components indicating a factor of safety of 1.5 at the design loads based on a suitable fatigue failure criteria is required to be submitted for review.

3 Materials

3.1 The materials used on the construction are to be manufactured and tested in accordance with Part 2.

3.2 The grades for various components to be analogous to relevant section of the Rules for propellers, shafting and gearing.

4 Design and construction

4.1 General

4.1.1 The arrangement of all types of thrusters is to be such that the craft can be manoeuvred in accordance with the design specifications.

4.1.2 The requirements associated with the structural and watertight integrity and the installation arrangement are to be in accordance with Part.3.

4.2 Azimuth thrusters

4.2.1 The following requirements are to be complied with:

a) The azimuthing mechanism is to be capable of a maximum rotational speed of not less than 1.5 rev/min.

b) Gearing for the azimuthing mechanism is to be designed in accordance with classification notes on the design of gearing.

Bevel gears will be specially considered on the basis of a conversion to equivalent helical gears.

i) Under dynamic operating conditions, the gear is to be considered for:

- Design maximum dynamic duty steering torque.
- Variable loading, where applicable.

A spectrum (duty) factor may be used. The load spectrum value is to be derived using load

measurements of similar units, where possible.

ii) Under a static duty (< 10^3 load cycles) steering torque. (for azimuth thruster with nozzle see 4.3.1).

iii) The following minimum factor of safety values are to be achieved:

Surface stress S_{Hmin} = 1.2

Bending Stress S_{Fmin} = 1.55.

c) For hydraulic pressure retaining parts and load bearing.

4.3 Azimuth thrusters with a nozzle

4.3.1 For steerable rudder propellers contained within a nozzle, the design lateral force F_r and the turning moment Q_r is to be calculated as follows:

$F_r = 376 . A . V^2$ [N]

$Q_r = F_r . r$ [N-m]

where,

A = projected area of nozzle [M^2]

V = Maximum service speed [knots] with the ship on summer load waterline. When the speed is less than 10 knots, V is to be replaced by the expression $V_{min} = (V+20)/3$

r = the horizontal distance from centre line of stock to centre of pressure of nozzle, but not to be taken less than 10% of the chord length of the nozzle.

The nozzle stock diameter in way of tiller, is to be not less than:

$$d_u = 4.2\sqrt[3]{Q_r K} \quad \text{[mm]}$$

where,

k = material factor for nozzle stock.

4.3.2 The scantlings of the nozzle stock or steering tube are to be such that the equivalent stress, σ,does not exceed 118/k [N/mm^2] i.e.

$$\sigma_e = \sqrt{\sigma^2 + 3\tau_t^2} \le 118/k \qquad \text{[N/mm}^2\text{]}$$

where,

σ is the bending stress [N/mm^2] calculated using the maximum bending moment, BM, on the nozzle stock or steering tube.

For nozzles without bottom support :

$$BM = \sqrt{F_r^2 + T^2}\,a \qquad \text{[Nm]}$$

T = Maximum thrust developed by the thruster [N]

F_r = design lateral force [N/mm^2] as per 4.3.1

a = Vertical distance from centre line of nozzle to the section under consideration [m] (See Figure 4.1).

τ_t is the torsional shear stress [N/mm^2] calculated using the torque Q_r as per 4.3.1.

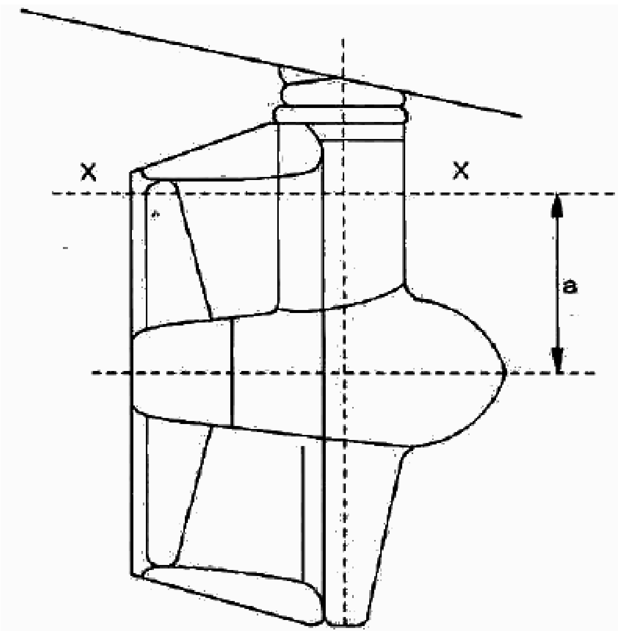


Figure 4.1 Azimuth thrusters

5 Piping systems

5.1 General

The piping system for azimuth thrusters is to comply with the general design requirements.

5.2 Azimuth thruster

The hydraulic power operating systems for each azimuth thruster are to be provided with the following:

a) Arrangements to maintain the cleanliness of the hydraulic fluid, taking into consideration the type and design of the hydraulic system.

b) A fixed storage tank having sufficient capacity to recharge at least one azimuth power actuating system including the reservoir. The piping from the storage tank is to be permanent and arranged in such a manner as to allow recharging from within the thruster space.

c) Where the lubricating oil for the azimuth thrusters is circulated under pressure, provision is to be made for the efficient filtration of the oil. The filters are to be capable of being cleaned without stopping the thruster or reducing the supply of filtered oil.

6 Control and monitoring

6.1 General

6.1.1 Azimuthing control for azimuth thruster(s) and propeller pitch control for azimuth and/or tunnel thruster(s) are to be provided from the navigating bridge, the main machinery control location and locally.

6.1.2 Means are to be provided at the remote control location(s) to stop each azimuth or tunnel thruster unit.

6.2 Monitoring and alarms

6.2.1 Alarms and monitoring requirements are indicated in 6.2.2, 6.2.3 and Table 6.1.

6.2.2 An indication of the angular position of the azimuth thruster(s) and the propeller pitch position for azimuth and/or tunnel thruster(s) are to be provided at each location from which it is possible to control the direction of thrust or the pitch.

6.2.3 All alarms associated with thruster unit faults are to be indicated individually on the navigating bridge and in accordance with the alarm system.

Table 6.1

Item	Alarm	Note
Thruster, azimuth or tunnel		Indicators, see 6.2.2
Azimuthing motor	Power failure, single phase	Also running indication on bridge and at machinery control location
Propeller pitch motor	Power failure	In case of failure the propeller pitch should be locked in full ahead position. Also running indication on bridge and at machinery control location
Electric propulsion motor	Overload, power failure	Also running indication on bridge and at machinery control location
Control system	Failure	
Hydraulic oil supply tank level	Low	
Hydraulic oil system pressure	Low	
Hydraulic oil system temperature	High	Where oil cooler is fitted
Hydraulic oil filters differential pressure	High	Where oil filters are fitted
Lubricating oil supply pressure	Low	If separate forced lubrication

7 Electrical systems

7.1 General

The electrical installation is to be designed, constructed and installed in accordance with the requirements of Part.4, Ch.2.

7.2 Emergency power for steering systems and drives. The arrangement to comply with rules requirements

7.3 Circuits

Azimuth thruster auxiliaries and controls are to be served by individual circuits. Services that are duplicated are to be separated throughout their length as widely as is practicable and without the use of common feeders, transformers, converters, protective devices or control circuits.

8 Tests

8.1 Azimuth thrusters

8.1.1 The performance specified for the craft is to be demonstrated.

8.1.2 The actual values of steering torque are to be verified during sea trials to confirm that the design maximum dynamic duty torque has not been exceeded.

8.2 Tunnel thrusters

It is to be demonstrated that the thruster unit meets the specified performance

Section 10 Vibrations and Alignment

1 Scope

1.1 The requirements of this Section are applicable to the following systems:

a) Main oil engine propulsion systems, except in the case of ships classed for smooth water service, when fitted with engines having powers less than 200 [kW].

b) Auxiliary oil engine machinery systems used for essential services, where the power developed by auxiliary engines is 200 [kW] and over.

c) Main propulsion systems formed by turbines or electric motors geared to the shafting and situated aft.

1.2 Unless otherwise advised, it is the responsibility of the Shipbuilder as the main contractor to ensure, in co-operation with the Engine builders, that the information required by this Section is prepared and submitted.

2 Basic system requirements

2.1 The systems are to be free from excessive torsional, axial and lateral vibration, and are to be aligned in accordance with tolerances agreed with the respective manufacturers.

2.2 Where changes are subsequently made to a dynamic system which has been approved, revised calculations are to be submitted for consideration.

3 Resilient mountings

3.1 Where the machinery is installed on resilient mountings, linear vibration (steady state and transient) is not to exceed the limiting values agreed with the manufacturers of the machinery nor those of the resilient mountings.

3.2 Misalignment arising from such vibration is not to impose excessive loading on machinery components within the system.

4 Torsional vibration

4.1 General

4.1.1 Torsional vibration calculations, including an analysis of the vibratory torques and stresses for the dynamic systems formed by the oil engines, turbines, motors, generators, flexible couplings, gearing, shafting and propeller, where applicable, including all branches, are to be submitted for approval together with the associated plans.

4.1.2 Particulars of the division of power developed throughout the speed range for turbines or from all intended combinations of operation in oil engine installations having more than one engine and/or with power take-off systems are to be submitted.

4.1.3 Any special speed requirements for prolonged periods in service are to be indicated, e.g., range of trawling revolutions per minute, range of operation revolutions per minute with a controllable pitch propeller, idling speed, etc.

4.1.4 The calculations and/or measurements carried out on oil engine installations containing transmission items sensitive to vibratory torque, e.g. gearing, flexible couplings, or generator rotors and their drives, are to take into account the effects of engine malfunction commonly experienced in service, such as cylinder(s) not firing.

4.1.5 Restricted speed ranges will be imposed in regions of speed where stresses are considered to be excessive for continuous running. Similar restrictions will be imposed, or other protective measures required to be taken, where vibratory torques are considered to be excessive for particular machinery items.

4.1.6 Where calculations indicate the possibility of excessive torsional vibration within the range of working speeds, torsional vibration measurements, using the appropriate recognized techniques, may be required to be taken from the machinery installation for the purpose of determining the need for restricted speed ranges.

4.2 Permissible limits of stresses due to torsional vibrations

4.2.1 Alternating torsional vibration stresses are stresses resulting from the alternating torque which is superimposed on the mean torque.

4.2.2 In no part of the propulsion system may the alternating torsional vibration stresses exceed the values of τ_1 for continuous operation and τ_2 for transient running.

4.2.3 For continuous operation the permissible stresses due to alternating torsional vibrations are not to exceed the following values:

$$\tau_1 = \pm\frac{\sigma B + 160}{18} C_k C_D (3 - 2\lambda^2) \qquad \text{for} \quad \lambda < 0.9$$

$$\tau_1 = \pm\frac{\sigma B + 160}{18} 1.38 C_k C_D \qquad \text{for} \quad 0.9 \le \lambda < 1.05$$

where,

τ_1 = permissible stress due to torsional vibrations for continuous operation [N/mm^2];

σB = tensile strength of shaft material [N/mm^2];

C_k = factor for different shaft design features as given in Table 4.1;

C_D = size factor = $0.35 + 0.93d^{-0.2}$;

d_o = shaft outside diameter under consideration [mm];

λ = speed ratio = n/n_o;

n = speed in rpm under consideration at rated power;

n_o = rated speed in rpm.

Table 4.1: C_k factors for different design features

Intermediate shafts with						Thrust shafts external to engines		Tailshafts		
Integral coupling flange and straight section	shrink fit couplings	Keyway, tapered connection	Keyway, cylindrical connection	Radial hole	Longitudinal slot[1)]	On both sides of thrust collar	In way of bearing when a roller bearing is used	Flange mounted or keyless taper fitted propellers	Key fitted propellers	Between forward end of aft most bearing and forward stern tube seal
C_k=1.0	1.0	0.60	0.45	0.50	0.30[2)]	0.85	0.85	0.55	0.55	0.80

Note:

1) The C_k value is valid for 1, 2 and 3 slots and they are to be arranged 360, 180 or 120 degrees apart from each other respectively.

2) C_k = 0.3 is a safe approximation within the limitations given in note No.6 under Table 2.1 of Sec. 7. If the slot dimensions are outside of the above limitations, or if the use of another C_k is desired, the actual stress concentration factor (scf) is to be documented or determined. In which case:

C_k = 1.45/scf

The scf is defined as the ratio between the maximum local principal stress and √3 times the nominal torsional stress (determined for the bored shaft without slots).

4.2.4 Where a vessel, because of its type of employment, is operated predominantly in the lower speed range, special consideration may be given to the permissible stresses for continuous operation.

4.2.5 Where the stresses exceed the limiting values of τ_1 for continuous operation, restricted speed ranges are to be imposed which are only allowed to be passed through rapidly.

4.2.6 Restricted speed ranges are not acceptable, in the speed range between 0.8 to 1.05 of the rated speed. The limits of the barred speed range are to be calculated in accordance with the following formula unless proved to be otherwise.

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

where, N_c = critical speed in [rpm].

4.2.7 For transient running the permissible stresses due to the alternating torsional vibrations are not, in any case, to exceed the values given by the following formula:

$$\tau_2 = \frac{1.7\tau_1}{\sqrt{C_k}} \quad \text{for} \quad \lambda \le 0.8$$

where,

τ_2 = permissible stress due to torsional vibrations for transient running.

5 Axial vibrations

5.1 For all main propulsion shafting systems, the Shipbuilders are to ensure that amplitudes due to axial vibrations are satisfactory throughout the speed range, so far as practicable. Where appropriate, amplitudes may be reduced by the use of suitable vibration dampers or phasing of propeller and engine, etc.

5.2 Unless previous experience of similar installation shows it to be unnecessary, calculations of the shafting system are to be carried out. These calculations are to include the effect of the thrust block seating and the surrounding hull structure taking part in the vibration. The result of these calculations or the evidence of previous experience is to be submitted for consideration.

5.3 Where calculations indicate the possibility of excessive axial vibration amplitudes within the range of working speeds, measurements using an appropriate recognized technique may be required to be taken from the shafting systems for the purpose of determining the need for restricted speed ranges.

6 Lateral vibrations

6.1 For all main propulsion shafting systems, the Shipbuilders are to ensure that amplitudes due to lateral vibrations are satisfactory throughout the speed range.

6.2 Unless previous experience of similar installations shows it to be unnecessary, calculations of lateral, or bending, vibration characteristics of the shafting system are to be carried out. These calculations, taking account of dynamic bearing stiffnesses, are to cover the frequencies giving rise to all critical speeds which may result in significant amplitudes within the speed range, and are to indicate relative deflections and bending moments throughout the shafting system.

6.3 The results of these calculations, or the evidence of previous experience, is to be submitted for consideration.

6.4 Where calculations indicate the possibility of excessive lateral vibration amplitudes within the range of working speeds, measurements using an appropriate recognized technique may be required to be taken from the shafting system for the purpose of determining the need for restricted speed ranges.

7 Shaft alignment

7.1 For main propulsion installations, the shafting is to be aligned to give reasonable bearing reactions, and bending moments, taking into consideration following factors:

- Forces which may affect the reliability of the propulsion shafting system including weight of the propeller and shafts,
- Hydrodynamic forces acting on the propeller,
- Number of propeller blades in relation to diesel engine cylinders,
- Misalignment forces,
- Thermal expansion,
- Flexibility of engine and thrust bearing foundations,

- Engine induced vibrations, gear tooth loadings, flexible couplings,
- Effect of power take-off,
- Effect of hull deformations at all conditions of ship loading and operation.

Consideration is also to be given to any limits of vibrations and loadings specified by the equipment manufacturer. The Shipbuilder is to position the bearings and construct the bearing seatings to minimize the effects of movements under all operating conditions.

7.2 For geared installations, where two or more pinions are driving the final reduction wheel, calculations are to be submitted to verify that shaft alignment is such that proper bearing reactions are maintained under all operating conditions.

7.3 Shaft alignment calculations are to be submitted for the following alignment-sensitive types of installations for review:

i) Propulsion shafting with power takeoff or with booster power arrangements.

ii) ii) Propulsion shafting for which the tail shaft bearings are to be slope bored.

iii) Propulsion shaft having diameter 300mm. and above in way of after most stern tube bearing

iv) Propulsion shafting arrangement requiring long shaft line.

The alignment calculations are to include bearing reactions, shear forces and bending moments along the shafting.

The alignment calculations are to be performed for the following conditions, as applicable:

- Theoretically aligned cold and hot conditions of the shaft with specified alignment tolerances.
- Deviation from the theoretical aligned conditions due to the forces exerted by power take-off or booster power.
- Calculations are to be performed for the maximum allowable alignment tolerances and are to show that:
- Bearing loads under all operating conditions are within the acceptable limits specified by the bearing manufacturer.
- Bearing reactions are always positive (i.e. supporting the shaft).
- Shear forces and bending moments on the shaft are within acceptable limits in association with other stresses in the shaft.
- Forces and moments on propulsion equipment are within the limits specified by the machinery manufacturers.

7.4 Shaft alignment is to be verified by measurement.

Section 11 Piping Systems

1 General

1.1 Application

a) General requirements applying to all piping systems for their design and construction, welding of steel pipes, bending of pipes, their arrangement and installation and their certification, inspection and testing are contained in sub-sections 2, 3, 4, 5 and 20 respectively.

b) Specific requirements for ship piping systems and machinery piping systems are given in sub-sections 6 to 19.

1.2 Documentation to be submitted

1.2.1 Documents

The documents listed in Table 1.1 are to be submitted.

1.2.2 Additional information

The information listed in Table 1.2 is also to be submitted.

Table 1.1: Documents to be submitted

Item No	I/A (1)	Document (2)
1	A	Drawing showing the arrangement of the sea chests and ship side valves
2	A	Diagram of the bilge and ballast systems(in and outside machinery spaces), including
		calculation for the bilge main, bilge branch lines and bilge pumps capacity as per Rule
3	A	requirements
4	A	Specification of the central priming system intended for bilge pumps, when provided
5	A	Diagram of the scuppers and sanitary discharge systems
6	A	Diagram of the air, sounding and overflow systems
7	A	Diagram of cooling systems (sea water and fresh water)
8	A	Diagram of fuel oil system
9	A	Drawings of the fuel oil tanks not forming part of the ship's structure
10	A	Diagram of the lubricating oil system
11	A	Diagram of the thermal oil system
12	A	Diagram of the hydraulic systems intended for essential services or located in machinery
13		spaces
	A	Diagram of steam system, including safety valve exhaust and drain pipes
	I	For high temperature steam pipes:
14	A	• stress calculation note
15	A	• drawing showing the actual arrangement of the piping in three dimensions
		Diagram of the boiler feed water and condensate system
		Diagram of the compressed air system, including:
		• starting air calculation as per Rule requirements
16	A	• procedure and preliminary calculation showing that after "dead ship conditions" the
17	A	propulsion may be restored within 30 min
18	A	Diagram of the hydraulic and pneumatic remote control systems
19	A	Diagram of the remote level gauging system
20	A	Diagram of the exhaust gas system
21	A	Diagram of drip trays and gutterway draining system
22	A	Arrangement of the ventilation system
		Diagram of the oxyacetylene welding system
		Drawings and specification of valves and accessories, where required in 2.7

(1) A = to be submitted for approval, in four copies;

I = to be submitted for information, in duplicate.

(2) Diagrams are also to include, where applicable, the (local and remote) control and monitoring systems and automation systems.

Table 1.2: 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 in 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 duplicate.

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 boilers, turbines, internal combustion engines and reduction gears.

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 boiler feed system is not to be less than 1.25 times the design pressure of the boiler or the maximum pressure expected in the feed piping, whichever is the greater.

c) The design pressure of steam piping located upstream of pressure reducing valves (high pressure side) is not to be less than the setting pressure of the boiler or superheater safety valves.

d) 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.

e) 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

a) Classes I, II and III are defined in Table 1.3

b) The following systems are not covered by Table 1.3:

- cargo piping for oil tankers, gas tankers and chemical tankers, and
- fluids for refrigerating plants.

Table 1.3: Class of piping systems

Media conveyed by the piping system	Class I	Class II (1) (4)	Class III (7)
Toxic media	without special safeguards (3)	not applicable	not applicable
Corrosive media	without special safeguards (3)	with special safeguards(3)	not applicable
Flammable media: • heated above flashpoint, or • having flashpoint < 60°C Liquefied gas	without special safeguards (3)	with special safeguards(3)	not applicable
Oxyacetylene	irrespective of p	not applicable	not applicable
Steam	$p > 1.6$ or $T > 300$	other (2)	$p \leq 0.7$ and $T \leq 170$
Thermal oil	$p > 1.6$ or $T > 300$	other (2)	$p \leq 0.7$ and $T \leq 150$
Fuel oil (8) Lubricating oil Flammable hydraulic oil (5)	$p > 1.6$ or $T > 150$	other (2)	$p \leq 0.7$ and $T \leq 60$
Other media (5) (6)	$p > 4$ or $T > 300$	other (2)	$p \leq 1.6$ and $T \leq 200$

(1) Valves under static pressure on oil fuel tanks or lubricating oil tanks belong to class II.

(2) Pressure and temperature conditions other than those required for class I and class III.

(3) Safeguards for reducing leakage possibility and limiting its consequences:

e.g. pipes led in positions where leakage of internal fluids will not cause a potential hazard or damage to surrounding areas which may include the use of pipe ducts, shielding, screening etc.

(4) Valves and fittings fitted on the ship side and collision bulkhead belong to class II. See also 20.4.3 b).

(5) Steering gear hydraulic piping system belongs to class I irrespective of p and T.

(6) Including water, air, gases, non-flammable hydraulic oil.

(7) The open ended pipes, irrespecitve of T, generally belong to class III (as drains, overflows, vents, exhaust gas lines, boiler escape pipes, etc).

(8) Design pressure for fuel oil systems is to be determined in accordance with Table 1.4.

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.

Note 3: Flammable media generally include the flammable liquids as oil fuel, lubricating oil, thermal oil and flammable hydraulic oil.

Table 1.4: Definition of the design pressure for fuel oil systems

Working pressure P, in bar	Working temperature T, in °C	
	$T \le 60$	$T > 60$
$P \le 7$	3 bar or max. working pressure, whichever is the greater	3 bar or max. working pressure, whichever is the greater
$P > 7$	max. working pressure	14 bar or max. working pressure, whichever is the greater

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 Table 2.1.

b) Materials for class I and class II piping systems are to be manufactured and tested in accordance with the appropriate requirements of Part II, Materials and Welding.

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 II, Materials and Welding.

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 dealt with in this Section are to be of a type approved by the Society.

Table 2.1: Conditions of use of metallic materials in piping systems

Material	Allowable classes	Maximum design temperature (1)	Particular conditions of use
Carbon and carbon-manganese steels	III, II,I	400 (2)	Class I and II pipes are to be seamless drawn pipes (3)
Copper and aluminium brass	III, II,I	200	• Not to be used in fuel oil systems, except for class III pipes of a diameter not exceeding 25 mm not passing through fuel oil tanks • Not to be used for boiler blow-down valves and pieces for connection to the shell plating (4)
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 to be used for sea water systems
Spheroidal graphite cast iron	III, II(5)	350	• 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 • Not to be used for boiler blow-down valves and pieces for connection to the shell plating
Grey cast iron	III, II(6)	220	Grey cast iron is not to be used for the following systems: • boiler blow-down systems and other piping systems subject to shocks, high stresses and vibrations • bilge lines in tanks • parts of scuppers and sanitary discharge systems located next to the hull below the freeboard deck or for passengers ships below the bulkhead deck • ship 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 and thermal oil systems
Aluminium and aluminium alloys	III, II	200	Aluminium and aluminium alloys are not to be used on the following systems: • flammable oil systems • sounding and air pipes of fuel oil tanks • fire-extinguishing systems • bilge system in boiler or machinery spaces or in spaces containing fuel oil tanks or pumping units • scuppers and overboard discharges except for pipes led to the bottoms or to the shell above the freeboard deck or fitted at their upper end with closing means operated from a position above the freeboard deck • boiler blow-down valves and pieces for connection to the shell plating

(1) Maximum design temperature is not to exceed that assigned to the class of piping.

(2) Higher temperatures may be accepted if metallurgical behaviour and time dependent strength (ultimate tensile strength after 100 000 hours) are in accordance with national or international standards or specifications and if such values are guaranteed by the steel manufacturer.

(3) Pipes fabricated by a welding procedure approved by the Society may also be used.

(4) Pipes made of copper and copper alloys are to be seamless.

(5) Use of spheroidal cast iron for class I piping systems will be given special consideration by the Society.

(6) Use of grey cast iron is not allowed when the design pressure exceeds 1.3 MPa.

Table 2.2: 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)
	Pipes in general(1)	Vent, overflow and sounding pipes for integral tanks (1) (5)	Sea water pipes, bilge and ballast systems (1)/ (4)		
10.2-12.0	1.6	–	–	–	–
13.5-19.3	1.8	–	–	–	–
20.0	2.0	–	–		
21.3-25.0	2.0	–	3.2	–	–
26.9-33.7	2.0	–	3.2	–	–
38.0-44.5	2.0	4.5	3.6	6.3	7.6
48.3	2.3	4.5	3.6	6.3	7.6
51.0-63.5	2.3	4.5	4.0	6.3	7.6
70.0	2.6	4.5	4.0	6.3	7.6
76.1-82.5	2.6	4.5	4.5	6.3	7.6
88.9-108.0	2.9	4.5	4.5	7.1	7.8
114.3-127.0	3.2	4.5	4.5	8.0	8.8
133.0-139.7	3.6	4.5	4.5	8.0	9.5
152.4-168.3	4.0	4.5	4.5	8.8	11.0
177.8	4.5	5.0	5.0	8.8	12.7
193.7	4.5	5.4	5.4	8.8	12.7
219.1	4.5	5.9	5.9	8.8	12.7
244.5-273.0	5.0	6.3	6.3	8.8	12.7
298.5-368.0	5.6	6.3	6.3	8.8	12.7
406.4-457.2	6.3	6.3	6.3	8.8	12.7

(1) Attention is drawn to the special requirements regarding:

- bilge and ballast systems
- scupper and discharge pipes
- sounding, air and overflow pipes
- ventilation systems
- oxyacetylene welding systems

- CO_2 fire-extinguishing systems
- cargo lines. The wall thickness is to be subject to special consideration by the Society.

(2) Reinforced wall thickness applies to pipes passing through tanks containing a fluid distinct from that conveyed by the pipe and to pipe connections fitted to the tanks.

(3) Extra-reinforced wall thickness applies to pipes connected to the shell below the freeboard deck.

(4) The minimum wall thickness for bilge lines and ballast lines through deep tanks is to be subject to special consideration by the Society. The ballast lines within oil cargo tanks (where permitted) is to be subject to special consideration by the Society.

(5) For sounding pipes, except those for flammable cargoes, the minimum wall thickness is intended to apply only to the part outside the tank.

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognized standards.

Note 2: For pipes efficiently protected against corrosion, the thickness may be reduced by an amount up to 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 and reduction in thickness due to bending.

Note 5: For nominal diameters ND > 450 mm, the minimum wall thickness is to be in accordance with a national or an international standard, but is not to be less than the minimum wall thickness of the appropriate column indicated for 450 mm pipe size.

Note 6: Exhaust gas pipe minimum wall thickness is to be subject to special consideration by the Society.

2.2 Thickness of pressure piping

2.2.1 Calculation of the thickness of pressure pipes

a) The thickness t, in mm, of pressure pipes is to be determined by the following formula but, in any case, is not to be less than the minimum thickness given in Tab 2.2 to Table 2.5.

$$t = \frac{t_0 + b + c}{1 - a/100}$$

where:

t_0 : Coefficient, in mm, equal to:

$$t_0 = \frac{P\,D}{2Ke + p}$$

with p and D : as defined in 1.4.1,

K : Permissible stress defined in 2.2.2, e : Weld efficiency factor to be:

- equal to 1 for seamless pipes and pipes fabricated according to a welding procedure approved by the Society,
- specially considered by the Society for other welded pipes, depending on the service and the manufacture procedure.

b : Thickness reduction due to bending defined in 2.2.3, in mm

c : Corrosion allowance defined in 2.2.4, in mm

a : Negative manufacturing tolerance percentage:

- equal to 10 for copper and copper alloy pipes, cold drawn seamless steel pipes and steel pipes fabricated according to a welding procedure approved by the Society,
- equal to 12.5 for hot laminated seamless steel pipes,
- subject to special consideration by the Society in other cases.

b) The thickness thus determined does not take into account the particular loads to which pipes may be subjected. Attention is to be drawn in particular to the case of high temperature and low temperature pipes.

Table 2.3: 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 the Society on a case by case basis, provided that it complies with recognized standards.

Table 2.4: Minimum wall thickness for austenitic stainless steel pipes

External diameter (mm)	Minimum wall thickness(mm)
10.2 to 17.2	1.0
21.3 to 48.3	1.6
60.3 to 88.9	2.0
114.3 to 168.3	2.3
219.1	2.6
273.0	2.9
323.9 to 406.4	3.6
over 406.4	4.0

Note 1: Diameters and thicknesses according to national or international standards may be accepted.

Table 2.5: Minimum wall thickness for aluminium and aluminium alloy pipes

External diameter (mm)	Minimum wall thickness (mm)
0 - 10	1.5
12 - 38	2.0
43 - 57	2.5
76 - 89	3.0
108 - 133	4.0
159 - 194	4.5
219 - 273	5.0
above 273	5.5

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognized standards.

Note 2: For sea water pipes, the minimum thickness is not to be less than 5 mm.

2.2.2 Permissible stress

a) The permissible stress K is given:

- in Table 2.6 for carbon and carbon-manganese steel pipes
- in Table 2.7 for alloy steel pipes, and
- in Table 2.8 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 Table 2.6 or Table 2.7, it is to be taken equal to the lowest of the following values:

$R_{m,20}/2.7, \quad R_e/A, \quad S_R/A, \qquad S$

where:

$R_{m,20}$: Minimum tensile strength of the material at ambient temperature (20°C), in N/mm^2

R_e : Minimum yield strength or 0,2% proof stress at the design temperature, in N/mm^2

S_R : Average stress to produce rupture in 100000 h at design temperature, in N/mm^2

S : Average stress to produce 1% creep in 100000 h at design temperature, in N/mm^2

A : Safety factor to be taken equal to:

- 1.6 when Re and S_R values result from tests attended by the Society
- 1.8 otherwise.

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

Table 2.6: Permissible stresses for carbon and carbon-manganese steel pipes

Specified minimum tensile strength (N/mm^2)	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 2.7: Permissible stresses for alloy steel pipes

Type of steel	Specified minimum tensile strength (N/mm^2)	Design temperature (°C)									
		≤50	100	200	300	350	400	440	450	460	470
1Cr1/2 Mo	440	159	150	137	114	106	102	101	101	100	99
2 ¼ Cr1 Mo annealed	410	76	67	57	50	47	45	44	43	43	44
2 ¼ Cr1Mo normalized and tempered below 750°C	490	167	163	153	144	140	136	130	128	127	116
2 ¼ Cr1Mo normalized and tempered above 750°C	490	167	163	153	144	140	136	130	122	114	105
½ Cr ½ Mo ¼ V	460	166	162	147	120	115	111	106	105	103	102

Type of steel	Specified minimum tensile strength (N/mm^2)	Design temperature (°C)									
		480	490	500	510	520	530	540	550	560	570
1Cr ½ Mo	440	98	97	91	76	62	51	42	34	27	22
2 ¼ Cr1 Mo annealed	410	42	42	41	41	41	40	40	40	37	32
2 ¼ Cr1Mo normalized and tempered below 750°C	490	106	96	86	79	67	58	49	43	37	32
2 ¼ Cr1Mo normalized and tempered above 750°C	490	96	88	79	72	64	56	49	43	37	32
½ Cr ½ Mo ¼ V	460	101	99	97	94	82	72	62	53	45	37

Table 2.8: Permissible stresses for copper and copper alloy pipes

Material (annealed)	Specified minimum tensile strength (N/mm^2)	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 2.9: Corrosion allowance for steel pipes

Piping system	Corrosion allowance (mm)
Superheated steam	0.3
Saturated steam	0.8
Steam coils in cargo tanks and liquid fuel tanks	2.0
Feed water for boilers in open circuit systems	1.5
Feed water for boilers in closed circuit systems	0.5
Blow-down systems for boilers	1.5
Compressed air	1.0
Hydraulic oil	0.3
Lubricating oil	0.3
Fuel oil	1.0
Thermal oil	1.0
Fresh water	0.8
Sea water	3.0
Refrigerants	0.3
Cargo systems for oil tankers	2.0
Cargo systems for ships carrying liquefied gases	0.3

Note 1: For pipes passing through tanks, an additional corrosion allowance is to be considered in order to account for the external corrosion.

Note 2: The corrosion allowance of pipes efficiently protected against corrosion may be reduced by no more than 50%.

Note 3: When the corrosion resistance of alloy steels is adequately demonstrated, the corrosion allowance may be disregarded.

2.2.3 Thickness reduction due to bending

a) Unless otherwise justified, the thickness reduction b due to bending is to be determined by the following formula:

$$b = \frac{Dt_0}{2.5\rho}$$

where:

ρ: Bending radius measured on the centre line of the pipe, in mm

D : as defined in 1.4.1

t_0 : as defined in 2.2.1.

b) When the bending radius is not given, the thickness reduction is to be taken equal to: 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 Table 2.9 and for non-ferrous metallic pipes in Table 2.10.

Table 2.10: Corrosion allowance for non-ferrous metal pipes

Piping material (1)	Corrosion allowance (mm) (2)
Copper	0.8
Brass	0.8
Copper-tin alloys	0.8
Copper-nickel alloys with less than 10% of Ni	0.8
Copper-nickel alloys with at least 10% of Ni	0.5
Aluminium and aluminium alloys	0.5

(1) The corrosion allowance for other materials will be specially considered by the Society. Where their resistance to corrosion is adequately demonstrated, the corrosion allowance may be disregarded.

(2) In cases of media with high corrosive action, a higher corrosion allowance may be required by the Society.

2.2.5 Tees

As well as complying with the provisions of 2.2.1 to 2.2.4, the thickness t_T of pipes on which a branch is welded to form a Tee is not to be less than that given by the following formula:

$$t_T = (1 + D_1 / D)\, t_0$$

where:

D_1 : External diameter of the branch pipe

D : As defined in 1.4.1

t_0 : As defined in 2.2.1.

Note 1: This requirement may be dispensed with for Tees provided with a reinforcement or extruded.

2.3 Calculation of high temperature pipes

2.3.1 General

For main steam piping having a design temperature exceeding 400°C, calculations are to be submitted to the Society concerning the stresses due to internal pressure, piping weight and any other external load, and to thermal expansion, for all cases of actual operation and for all lengths of piping.

The calculations are to include, in particular:

- the components, along the three principal axes, of the forces and moments acting on each branch of piping
- the components of the displacements and rotations causing the above forces and moments
- all parameters necessary for the computation of forces, moments and stresses.

In way of bends, the calculations are to be carried out taking into account, where necessary, the pipe ovalisation and its effects on flexibility and stress increase.

A certain amount of cold springing, calculated on the basis of expected thermal expansion, is to be applied to the piping during installation. Such springing is to be neglected in stress calculations; it may, however, be taken into account in terms of its effect on thrusts on turbines and other parts.

2.3.2 Thermal stress

The combined stress σ_{ID}, in N/mm^2, due to thermal expansion, calculated by the following formula:

$$\sigma_{ID} = \sqrt{\left(\sigma^2 + 4\tau^2\right)}$$

is to be such as to satisfy the following equation:

$$\sigma_{ID} \leq 0.75K_{20} + 0.25K_T$$

where:

σ: Value of the longitudinal stress due to bending moments caused by thermal expansion, increased, if necessary, by adequate factors for bends, in N/mm^2; in general it is not necessary to take account of the effect of axial force

τ: Value of the tangential stress due to torque caused by thermal expansion, in N/mm^2; in general it is not necessary to take account of the effect of shear force

K_{20} : Value of the permissible stress for the material employed, calculated according to 2.2.2, for a temperature of 20°C, in N/mm^2

K_T : Value of the permissible stress for the material employed, calculated according to 2.2.2, for the design temperature T, in N/mm^2.

2.3.3 Longitudinal stresses

The sum of longitudinal stresses σ_L , in N/mm^2, due to pressure, piping weight and any other external loads is to be such as to satisfy the following equation:

$\sigma_L \leq K_T$

where K_T is defined in 2.3.2.

2.3.4 Alternative limits for permissible stresses

Alternative limits for permissible stresses may be considered by the Society in special cases or when calculations have been carried out following a procedure based on hypotheses other than those considered above.

2.4 Junction of pipes

2.4.1 General

a) The junctions between metallic pipe lengths or between metallic pipe lengths and fittings are to be made by:

- direct welding (butt-weld, socket-weld)
- bolted flanges (welded-on or screwed-on)
- threaded sleeve joints, or
- mechanical joints (see 2.4.5).

The joints are to comply with a recognized standard or to be of a design proven to be suitable for the intended purpose and acceptable to the Society. See also 2.1.2.

The expression "mechanical joints" means devices intended for direct connection of pipe lengths other than by welding, flanges or threaded joints described in 2.4.2 to 2.4.4.

b) The number of joints in flammable oil piping systems is to be kept to the minimum necessary for mounting and dismantling purposes.

c) The gaskets and packings used for the joints are to suit the design pressure, the design temperature and the nature of the fluids conveyed.

d) The junction between plastic pipes is to comply with App 1.

2.4.2 Welded metallic joints

a) Welded joints are to be used in accordance with Table 2.11.

Welding and non destructive testing of welds are to be carried out in accordance with 3.

b) Butt-welded joints are to be of full penetration type, with or without special provision for a high quality of root side.

The expression "special provision for a high quality of root side" means that butt welds were accomplished as double welded or by use of a backing ring or inert gas back-up on first pass, or other similar methods accepted by the Society.

c) Slip-on sleeve and socket welded joints are to have sleeves, sockets and weldments of adequate dimensions in compliance with a standard recognized by the Society.

2.4.3 Metallic flange connections

a) In general, the metallic flange connections used for piping systems are to be in compliance with a standard recognized by the Society.

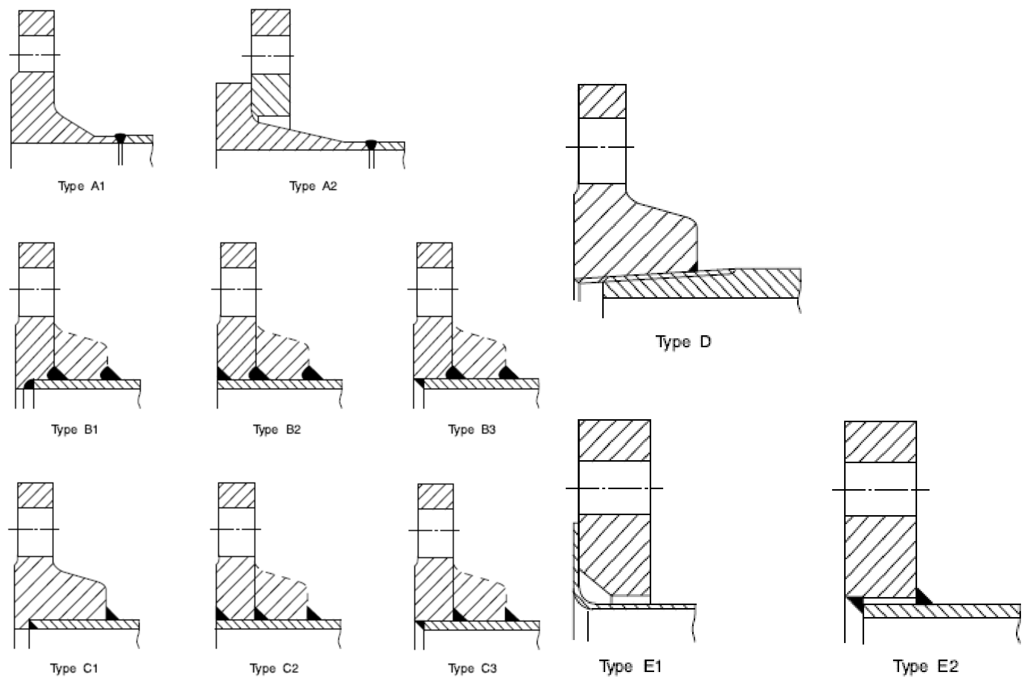
b) The material used for flanges and gaskets is to be suitable for the nature and temperature of the fluid, as well as pipes on which the flanges are to be fitted.

c) The dimensions and configuration of flanges and bolts are to be chosen in accordance with recognized standard intended for design pressure and design temperature of the piping system. Otherwise, the flange connections are subject to special consideration.

d) Flanges are to be attached to the pipes by welding or screwing. Examples of acceptable metallic flange connections are shown in Figure 2.1. However, other types of flange connections may be also considered by the Society in each particular case, provided that they are in accordance with national or international standards applicable to the piping system and recognize the boundary fluids, design pressure and temperature conditions, external or cyclic loading and location.

e) Permitted applications are indicated in Table 2.12.

Figure 2.1: Examples of metallic flange connections



Note 1: For type D, the pipe and flange are to be screwed with a tapered thread and the diameter of the screw portion of the pipe over the thread is not to be appreciably less than the outside diameter of the unthreaded pipe. For certain types of thread, after the flange has been screwed hard home, the pipe is to be expanded into the flange.

Note 2: The leg length of the fillet weld, as well as the dimension of the groove penetration in the flange, is to be in general equal to 1.5 times the pipe thickness but not less than 5 mm.

Table 2.11: Use of welded and threaded metallic joints in piping systems

Joints	Permitted classes of piping	Restrictions of use
Butt-welded, with special provision for a high quality of root side (1)	III, II, I	no restrictions
Butt-welded, without special provision for a high quality of root side (1)	III, II	no restrictions
Slip-on sleeve and socket welded(2)	III	no restrictions
Threaded sleeve joints with tapered thread (3)	I	not allowed for: • pipes with outside diameter of more than 33.7 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur (4).
	III, II	not allowed for: • pipes with outside diameter of more than 60.3 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur (4).
Threaded sleeve joints with parallel thread and tightening suitable for intended design conditions (3)	III	not allowed for: • pipes with outside diameter of more than 60.3 mm • pipes inside tanks • piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur (4).

(1) For expression “special provision for a high quality of root side” see 2.4.2 b).

(2) Particular cases may be allowed by the Society for piping systems of Class I and II having outside diameter ≤ 88.9 mm except for piping systems conveying toxic media or services where fatigue, severe erosion or crevice corrosion is expected to occur.

(3) In particular cases, sizes in excess of those mentioned above may be accepted by the Society if found in compliance with a recognized national and/or international standard.

(4) May be accepted for accessory lines and instrumentation lines with external diameters up to 25 mm.

Note 1: Other applications will be specially considered by the Society.

Table 2.12: Use of metallic flange connections in piping systems (types as shown in Figure 2.1)

Type of media conveyed	Class of piping (see Table 1.3)		
	I	II	III
Flammable liquids (where heated above flashpoint or having flashpoint < 60°C) Liquefied gases	A1, A2, B1, B2, B3 (1) (2) (4)	A1, A2, B1, B2, B3, C1, C2, C3 (1) (4)	not applicable
Fuel oil Lubricating oil	A1, A2, B1, B2, B3	A1, A2, B1, B2, B3, C1, C2, C3	A1, A2, B1, B2, B3, C1, C2, C3, E2
Steam Thermal oil	A1, A2, B1, B2, B3 (2) (3)	A1, A2, B1, B2, B3, C1, C2, C3, D, E2 (6)	A1, A2, B1, B2, B3, C1, C2, C3, D, E2
Other media as water, air, gases (refrigerants), nonflammable hydraulic oil, etc	A1, A2, B1, B2, B3 (3)	A1, A2, B1, B2, B3, C1, C2, C3, D, E2 (6)	A1, A2, B1, B2, B3, C1, C2, C3, D, E1, E2 (5) (6) (7)

(1) When design pressure p (see 1.3.2) exceeds 1 MPa, types A1 and A2 only.

(2) For nominal diameter ND ≥ 150 mm, types A1 and A2 only.

(3) When design temperature T (see 1.3.3 exceeds 400°C, types A1 and A2 only.

(4) For cargo piping of chemical carriers, IBC Code Ch. 5, 5.3 is to be applied. For cargo piping of gas carriers, IGC Code Ch. 5, 5.4 is to be applied.

(5) Type E2 only, for design pressure p ≤ 1,6 Mpa and design temperature T ≤ 150°C.

(6) Types D and E1 only, for design temperature T ≤ 250°C.

(7) Type E1 only, for water pipelines and for open ended lines (e.g. drain, overflow, air vent piping, etc.).

2.4.4 Slip-on threaded joints

a) 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 recognized national or international standard and are to be acceptable to the Society.

b) Slip-on threaded joints may be used for piping systems in accordance with Table 2.11.

c) Threaded joints may be accepted also in CO_2 piping systems, provided that they are used only inside protected spaces and in CO_2 cylinder rooms.

2.4.5 Mechanical joints

Due to the great variations in design and configuration of mechanical joints, specific recommendation regarding calculation method for theoretical strength calculations is not specified. The Type Approval is to be based on the results of testing of the actual joints. Below specified requirements are applicable to pipe unions, compression couplings, slip-on joints as shown in Figure 2.2. Similar joints complying with these requirements may be acceptable.

a) The application and pressure ratings of different mechanical joints are to be approved by the Society.

The approval is to be based on the Type Approval procedure. 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.

b) 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.

c) 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.

d) Material of mechanical joints is to be compatible with the piping material and internal and external media.

e) As far as applicable, the mechanical joints are to be tested to a burst pressure of 4 times the design pressure.

For design pressures above 200 bar the required burst pressure is to be specially considered by the Society.

f) In general, mechanical joints are to be of fire resistant type as required by Table 2.13.

g) Mechanical joints, which in the event of damage could cause fire or flooding, are not to be used in piping sections directly connected to the shell openings or tanks containing flammable fluids.

h) The 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.

i) The number of mechanical joints in flammable liquid systems is to be kept to a minimum. In general, flanged joints conforming to recognized standards are to be used.

j) 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.

k) Slip-on joints are not to be used in pipelines in cargo holds, tanks, and other spaces which are not easily accessible, unless approved by the Society. 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 of lateral pipe deformation is necessary. Usage of these joints as the main means of pipe connection is not permitted.

l) Application of mechanical joints and their acceptable use for each service is indicated in Table 2.13; dependence upon the class of piping, pipe dimensions, working pressure and temperature is indicated in Table 2.14.

m) In some particular cases, sizes in excess of those mentioned above may be accepted by the Society if they are in compliance with a recognized national and/or international standard.

n) Application of various mechanical joints may be accepted as indicated by Table 2.13. However, in all cases, acceptance of the joint type is to be subject to approval for the intended application, and subject to conditions of the approval and applicable Rules.

o) Mechanical joints are to be tested in accordance with a program approved by the Society, which is to include at least the following:

1) leakage test
2) vacuum test (where necessary)
3) vibration (fatigue) test
4) fire endurance test (where necessary)
5) burst pressure test
6) pressure pulsation test (where necessary)
7) assembly test (where necessary)
8) pull out test (where necessary).

p) The installation of mechanical joints is to be in accordance with the manufacturer's assembly instructions.

Where special tools and gauges are required for installation of the joints, these are to be supplied by the manufacturer.

2.5 Protection against overpressure

2.5.1 General

a) These requirements deal with the protection of piping systems against overpressure, with the exception of heat exchangers and pressure vessels.

b) Safety valves are to be sealed after setting.

Figure 2.2: Examples of mechanical joints

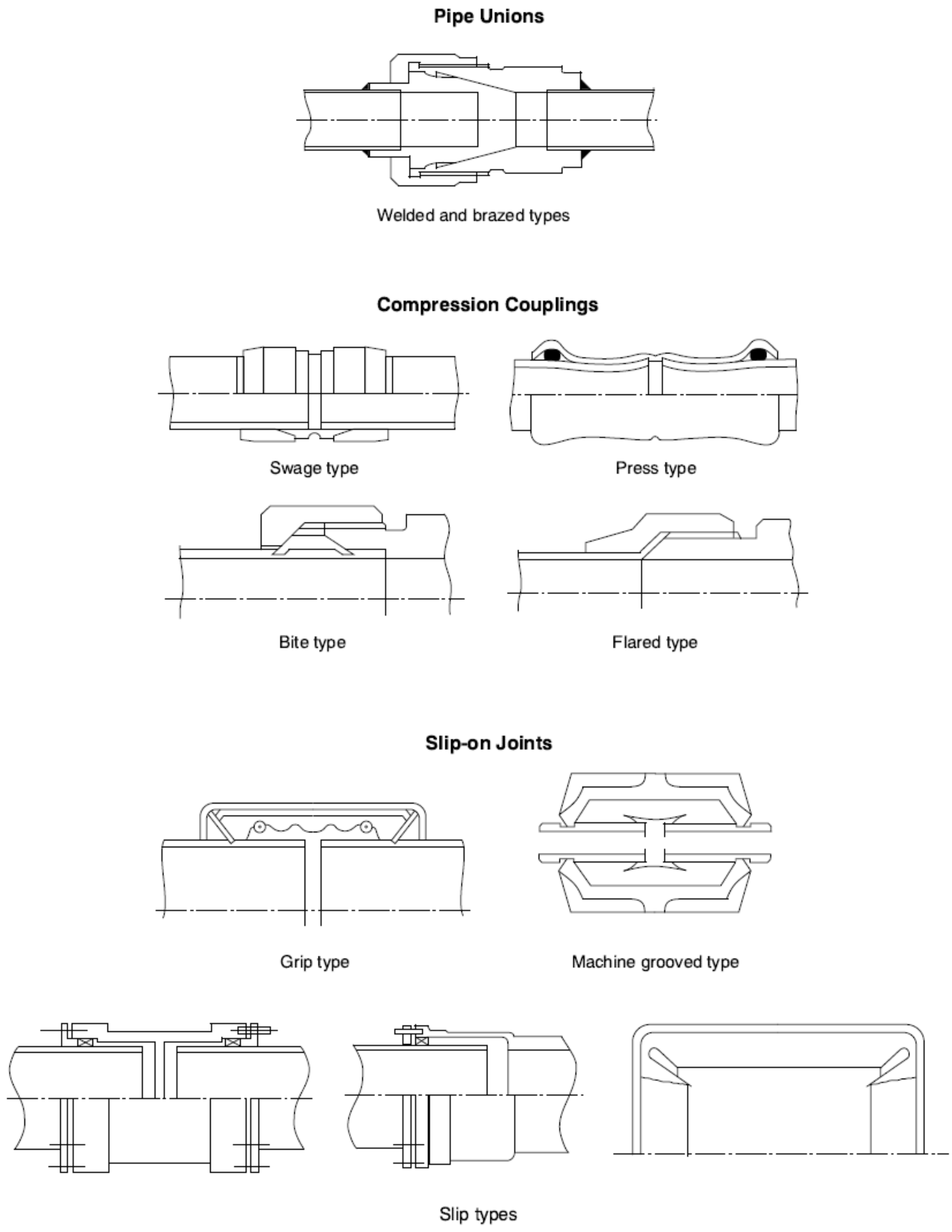


Table 2.13: Application of mechanical joints

Systems		Kind of connections		
		Pipe unions	Compression couplings (6)	Slip-on joints
Flammable fluids (flash point ≤ 60°C)				
1	Cargo oil lines	+	+	+ (5)
2	Crude oil washing lines	+	+	+ (5)
3	Vent lines	+	+	+ (3)
Inert gas				
4	Water seal effluent lines	+	+	+
5	Scrubber effluent lines	+	+	+
6	Main lines	+	+	+ (2) (5)
7	Distribution lines	+	+	+ (5)
Flammable fluids (flash point > 60°C)				
8	Cargo oil lines	+	+	+ (5)
9	Fuel oil lines	+	+	+ (2) (3)
10	Lubricating oil lines	+	+	+ (2) (3)
11	Hydraulic oil	+	+	+ (2) (3)
12	Thermal oil	+	+	+ (2) (3)
Sea water				
13	Bilge lines	+	+	+ (1)
14	Fire main and water spray	+	+	+ (3)
15	Foam system	+	+	+ (3)
16	Sprinkler system	+	+	+ (3)
17	Ballast system	+	+	+ (1)
18	Cooling water system	+	+	+ (1)
19	Tank cleaning services	+	+	+
20	Non-essential systems	+	+	+
Fresh water				
21	Cooling water system	+	+	+ (1)
22	Condensate return	+	+	+ (1)
23	Non-essential systems	+	+	+
Sanitary/Drains/Scuppers				
24	Deck drains (internal)	+	+	+ (4)
25	Sanitary drains	+	+	+
26	Scuppers and discharge (overboard)	+	+	-
Sounding/Vent				
27	Water tanks/Dry spaces	+	+	+
28	Oil tanks (flash point > 60°C)	+	+	+ (2) (3)
Miscellaneous				
29	Starting/Control air	+	+	-
30	Service air (non-essential)	+	+	+
31	Brine	+	+	+
32	CO2 system	+	+	-
33	Steam	+	+	+ (7)

Note 1:

+ : Application is allowed

−: Application is not allowed.

(1) Inside machinery spaces of category A - only approved fire resistant types.

(2) Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.

(3) Approved fire resistant types.

(4) Above free board deck only.

(5) In pump rooms and open decks - only approved fire resistant types.

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

(7) Restrained slip-on joints (which are provided with stopping bolts for axially restraining the coupling from pull-out) may be accepted in steam lines on open decks with a design pressure of 10 bar or less, provided that the associated pipes are suitably supported and anchored.

Table 2.14: Application of mechanical joints depending upon the class of piping

Types of joints	Classes of piping systems		
	Class I	Class II	Class III
Pipe Unions			
Welded and brazed types	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Compression Couplings			
Swage type	+	+	+
Bite type	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Flared type	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Press type	-	-	+
Slip-on Joints			
Machine grooved type	+	+	+
Grip type	-	+	+
Slip type	-	+	+

Note 1:

+ : Application is allowed

_ : Application is not allowed.

2.5.2 Protection of flammable oil systems

Provisions shall be made to prevent overpressure in any flammable oil tank or in any part of the flammable oil systems, including the filling lines served by pumps on board.

2.5.3 Protection of pump and compressor discharges

a) Provisions are to be made so that the discharge pressure of pumps and compressors cannot exceed the pressure for which the pipes located on the discharge of these pumps and compressors are designed.

b) When provided on the pump discharge for this purpose, safety valves are to lead back to the pump suction or to any other suitable place.

c) The discharge capacity of the safety valves installed on pumps and compressors is to be such that the pressure at the discharge side cannot exceed by more than 10% the design pressure of the discharge pipe in the event of operation with closed discharge.

2.5.4 Protection of pipes

a) Pipes likely to be subjected to a pressure exceeding their normal working pressure are to be provided with safety valves or equivalent overpressure protecting devices.

b) In particular, pipes located on the low pressure side of pressure reducing valves are to be provided with safety valves unless they are designed for the maximum pressure on the high pressure side of the pressure reducing valve. See also 1.3.2 and 2.9.1.

c) The discharge capacity of the devices fitted on pipes for preventing overpressure is to be such that the pressure in these pipes cannot exceed the design pressure by more than 10%.

2.6 Flexible hoses and expansion joints

2.6.1 General

a) Definitions:

- Flexible hose assembly: short length of metallic or non-metallic hose normally with prefabricated end fittings ready for installation
- Expansion joint: an assembly designed to safely absorb the heat-induced expansion and contraction, to allow relative movement between pipes and the ship's structure as required in 5.6.

b) Flexible hoses and expansion joints are to be of a type approved by the Society. Unless otherwise specified, they are to comply with the requirements of this sub-article.

c) The requirements of this sub-article apply to flexible hoses and expansion joints of metallic or non-metallic material intended for a permanent connection between a fixed piping system and items of machinery. The requirements may also be applied to temporary connected flexible hoses or hoses of portable equipment.

d) Unless otherwise specified, the requirements of this sub-article do not apply for flexible hose assemblies and expansion joints intended to be used in fire extinguishing systems.

e) Flexible hose assemblies and expansion joints intended for piping systems with a design temperature below the ambient temperature are subject to special consideration by the Society.

f) Specific requirements for flexible hoses and expansion joints intended for cargo pipe lines are given in the corresponding parts of the rules.

2.6.2 Conditions of use of flexible hoses and expansion joints

a) Unless otherwise specified, the Society may permit the use of flexible hoses and expansion joints, both in metallic and non-metallic materials, provided they are approved for the intended service. They may be accepted for use in oil fuel, lubricating, hydraulic and thermal oil systems, fresh water and sea water cooling systems, compressed air systems, bilge and ballast systems, Class III steam systems and exhaust gas systems where they comply with the requirements of this sub-article.

b) For steam systems, the flexible hose assemblies and expansion joints are to be of metallic constructions.

c) The position of flexible hose assemblies and expansion joints is to be clearly shown on the drawings listed in 1.2.1 and 1.2.2 when submitted to the Society.

d) Flexible hose assembly or an expansion joint is 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 and any requirements of the Society.

e) Flexible hose assembly or an expansion joint is not accepted in high pressure fuel oil injection systems.

f) The use of non-metallic expansion joints on pipes connected inboard to sea inlet valves and overboard discharge valves below the bulkhead deck is to be subject to a special consideration by the Society. Unless the above-mentioned valves are fitted with remote controls operable from above the freeboard deck, suitable means are to be provided to limit the flooding of the ship in the event of rupture of the expansion joints.

g) The 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, is to be subject to special consideration.

h) The arrangement and installation of the flexible hose assemblies and expansion joints are also to comply with 5.9.3.

2.6.3 Design of flexible hoses and expansion joints

a) Flexible hoses and expansion joints are to be designed and constructed in accordance with recognized National or International standards acceptable to the Society.

Note 1: Documentation and calculation of expansion joints may be carried out in accordance with the Expansion Joint Manufacturers Association (EJMA) standard.

b) The material, design and construction are to be at least suitable for:

- marine environment and external contact with hydrocarbons
- internal contact and resistance to the fluid they are to convey
- maximal pressure and temperature of fluid they are to convey
- maximum expected forces due to vibrations

- maximum expected impulse peak pressure
- bursting pressure at the service temperature in accordance with 2.6.4.

The metallic materials are to comply with 2.1.2.

c) Where rubber materials are intended for use in bilge, ballast, compressed air, oil fuel, lubricating, hydraulic and thermal oil systems, the construction is to incorporate a single, double or more, closely woven integral wire braid or other suitable material reinforcement acceptable to the Society.

Flexible hoses of plastic 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.

Rubber or plastic material hoses used in oil supply lines to burners are to have external wire braid protection in addition to the reinforcement mentioned above.

d) Flexible hose assemblies and expansion joints constructed of non-metallic materials, which are intended for installation in piping systems for flammable media or in sea water systems where failure may result in flooding, are to be of fire-resistant type.

Fire resistance is to be demonstrated by testing in accordance with standard specified in 2.6.4.

e) Flexible hoses and expansion joints are to be complete with approved end fittings in accordance with manufacturer's specification. The end connections that do not have a flange are to comply with 2.4.5 as applicable and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose with particular reference to pressure and impulse tests.

f) The hose clamps and similar types of end attachments are not acceptable for use 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 that there are double clamps at each end connection.

g) The expansion joints intended for use in sea water systems are to be provided with suitable guards which effectively enclose and reduce to the minimum practicable any flow of water into the machinery spaces in the event of failure of the flexible elements. However, the guards are not to interfere with the action of the expansion joint.

2.6.4 Testing

a) Acceptance of a flexible hose assembly or an expansion joint is subject to satisfactory prototype testing. Prototype test programmes are to be submitted by the manufacturer and are to be sufficiently detailed to demonstrate performance in accordance with the specified standards.

b) Prototype test programmes are to be made in accordance with recognized standards which are suitable for the intended service of the flexible hose or of an expansion joint.

c) For a particular flexible hose or an expansion joint type complete with end fittings, the tests (see 2.6.4, Note 1), as applicable, are to be carried out on different nominal diameters for pressure, burst, impulse resistance and fire resistance in accordance with the requirements of the relevant standard recognized by the Society.

Tests are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to the installation.

At least the following standards are to be used, as applicable:

- ISO 6802 - Rubber and plastics hoses and hose assemblies with wire reinforcements – Hydraulic pressure impulse test with flexing
- ISO 6803 - Rubber and plastics hoses and hose assemblies - Hydraulic pressure impulse test without flexing
- ISO 15540 - Ships and marine technology – Fire resistance of hose assemblies - Test methods
- ISO 15541 - Ships and marine technology – Fire resistance of hose assemblies - Requirements for test bench
- ISO 10380 – Pipe work - Corrugated metal hoses and hose assemblies.

Other standards may be accepted where agreed by the Society.

Note 1: For minimal scope of prototype testing, see also 20.2.1.

d) All flexible hose assemblies or expansion joints are to be satisfactorily prototype burst tested to an international standard (see 2.6.4, Note 2) to demonstrate they are able to withstand a pressure not less than 4 times its design pressure without indication of failure or leakage.

Exemptions from this requirement may be granted for expansion joints of large diameter used on sea water lines and to expansion joints used on exhaust gas lines.

Note 2: The international standards, e.g. EN or SAE for burst testing of non-metallic hoses, require the pressure to be increased until burst without any holding period at 4 MWP.

2.6.5 Marking

Flexible hoses or expansion joints are to be permanently marked by the manufacturer with the following details:

- manufacturer's name or trademark
- date of manufacture (month/year)
- designation type reference
- nominal diameter
- pressure rating
- temperature rating.

Where a flexible hose assembly or an expansion joint is made up of items from different manufacturers, the components are to be clearly identified and traceable to evidence of prototype testing.

2.7 Valves and accessories

2.7.1 General

a) Valves and accessories are normally to be built in accordance with a recognized standard. Otherwise, they are subject to special consideration for approval by the Society.

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.

Valves and accessories which are fitted:

- in a class I piping system, or
- in a class II piping system, or
- on the ship side, on the collision bulkhead, on fuel oil tanks or on lubricating oil tanks under static pressure, are to be subject to the applicable testing and inspection required by the Rules. See 20.6.1.

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.

2.7.2 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 2.4.

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.

2.7.3 Valves with remote control

a) Unless otherwise specified, the valves and cocks which can not be fitted in places where they are at all times readily accessible are to be provided with remote control.

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. For shipside valves and valves on the collision bulkhead, the means for local manual operation are to be permanently attached.

c) For submerged valves in ballast, cargo, or other tanks where accepted by the Society, local manual operation may be by extended spindle or portable hand pump.

The manual operation by hand pump is to have the control lines to each submerged valve provided with the quick coupling connections, as close to the valve actuator as practicable, to allow easy connection of the hand pump. For shipside valves and valves on the collision bulkhead, the hand pump is to be permanently attached and fitted to the quick coupling connection. For other valves, not less than two portable hand pumps are to be provided.

d) 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.

e) Power failure of the remote control system is not to cause an undesired change of the valve position.

f) Unless otherwise specified, indicators are to be provided on the remote controls to show whether the valves are open or closed.

The indicators for local manual control are to comply with 2.7.2, item e).

2.8 Sea inlets and overboard discharges

2.8.1 General

a) Except where expressly stated in 8, the requirements of this sub-article do not apply to scuppers and sanitary discharges.

b) Unless otherwise specified, the number of sea inlets is to be as stated in 10.7.

c) The sea inlets are to comply also with the requirements specified for particular service notations or additional class notations.

2.8.2 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 ship.

b) Sea inlets and overboard discharges are to be fitted with valves complying with 2.7 and 2.8.3.

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 ship.

e) Sea inlets are to be fitted with gratings complying with 2.8.4.

f) Provisions are to be made for clearing sea inlet gratings.

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

h) Sea water suction lines are to be fitted with strainers having a free passage area of at least twice that of the sea suction valve.

2.8.3 Valves

a) Sea inlet and overboard discharge valves are to be secured:

- directly on the shell plating, or
- on sea chests built on the shell plating, with scantlings in compliance with Part III of the Rules, or
- on extra-reinforced and short distance pieces attached to the shell (see Table 2.2).

b) The bodies of the valves and distance pieces are to have a spigot passing through the plating without projecting beyond the external surface of such plating or of the doubling plates and stiffening rings, if any.

c) Valves are to be secured by means of:

- bolts screwed through the plating with a countersunk head, or
- studs screwed in heavy pads themselves secured to the hull or chest plating, without penetration of the plating by the stud holes.

d) The use of butterfly valves will be specially considered by the Society. In any event, butterfly valves not fitted with flanges are not to be used for water inlets or overboard discharges unless provisions are made to allow disassembling at sea of the pipes served by these valves without any risk of flooding.

e) The materials of the valve bodies and connecting pieces are to comply with Table 2.1.

f) Ship side valves serving piping systems made of plastics are to comply with App 1, 3.7.1.

g) In manned machinery spaces, the valves may be controlled locally and shall be provided with indicators showing whether they are open or closed. Location of controls shall comply with 5.5.4.

2.8.4 Gratings

a) Gratings are to have a free flow area not less than twice the total section of the pipes connected to the inlet.

b) When gratings are secured by means of screws with a countersunk head, the tapped holes provided for such screws are not to pass through the plating or doubling plates outside distance pieces or chests.

c) Screws used for fixing gratings are not to be located in the corners of openings in the hull or of doubling plates.

d) In the case of large sea inlets, the screws used for fixing the gratings are to be locked and protected from corrosion.

e) When gratings are cleared by use of compressed air or steam devices, the chests, distance pieces and valves of sea inlets and outlets thus arranged are to be so constructed as to withstand the maximum pressure to which

they may be subjected when such devices are operating.

f) For additional class notation IN WATER SURVEY, specific requirements apply.

2.8.5 Ship side connections for blow-down of boilers

a) Blow-down pipes of boilers are to be provided with cocks or valves placed as near the end of the pipes as possible, while remaining readily accessible and located above the engine room floor.

b) Blow-down valves are to be so designed that it is easy to ascertain whether they are open or shut. Where cocks are used, the control keys are to be such that they cannot be taken off unless the cocks are shut. Where valves are used, the control-wheels are to be permanently fixed to the spindle.

c) A protection ring is to be fitted on the shell plating, outside, at the end of the blow-down pipes. The spigot of the valve referred to in 2.8.3, item b), is to pass through this ring.

2.9 Control and monitoring

2.9.1 General

a) Local indicators are to be provided for at least the following parameters:

- pressure, in pressure vessels, at pump or compressor discharge, at the inlet of the equipment served, on the low pressure side of pressure reducing valves
- temperatures, in tanks and vessels, at heat exchanger inlet and outlet
- levels, in tanks and vessels containing liquids.

b) Safeguards are to be provided where an automatic action is necessary to restore acceptable values for a faulty parameter.

c) Automatic controls are to be provided where it is necessary to maintain parameters related to piping systems at a pre-set value.

2.9.2 Level gauges

Level gauges used in flammable oil systems are to be of a type approved by the Society and are subject to the following conditions:

- in passenger ships, they are not to require penetration below the top of the tank and their failure or overfilling of the tanks is not to permit release of fuel
- in cargo ships, their failure or overfilling of the tank is not to permit release of fuel into the space. The use of cylindrical gauges is prohibited. The Society

may permit the use of oil-level gauges with flat glasses and self-closing valves between the gauges and fuel tanks.

- their glasses are to be made of heat-resistant material and efficiently protected against shocks.

Note 1: On cargo ships of less than 500 tons gross tonnage and non-propelled ships:

- cylindrical gauges may be used provided they are fitted with self-closing valves at their lower end as well as at their upper end if the latter is below the maximum liquid level
- in the case of tanks not subject to filling by power pumps, with the exception of fuel oil service tanks, the valves need not be of the self-closing type. Such valves are, however, to be readily accessible and instruction plates are to be fitted adjacent to them specifying that they are to be kept closed.

3 Welding of steel piping

3.1 Application

3.1.1

a) The following requirements apply to welded joints belonging to class I or II piping systems.

They may also be applied to class III piping systems, at the discretion of the Society.

b) This article does not apply to refrigerated cargo installation piping systems operating at temperatures lower than minus 40°C.

c) The requirements for qualification of welding procedures are given in Part 2 Materials and Welding.

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 Figure 2.1 and for the fixing of branch pipes, joints between pipes and between pipes and fittings are to be of the butt-welded type. However, for class I pipes with an internal diameter not exceeding 50 mm and for class II pipes, socket welded connections of approved types may be used.

b) For butt-welded joints between pipes or between pipes and flanges or other fittings, correctly adjusted backing rings may be used; such rings are to be either of the same grade of steel as the elements to be welded or of such a grade as not to adversely influence the weld; if the backing ring cannot be removed after welding, it is to be correctly profiled.

3.3.2 Assembly of pipes of unequal thickness

If the difference of thickness between pipes to be butt welded exceeds 10% of the thickness of the thinner pipe plus 1 mm, subject to a maximum of 4 mm, the thicker pipe is to be thinned down to the thickness of the thinner pipe on a length at least equal to 4 times the offset, including the width of the weld if so desired.

3.3.3 Accessories

a) When accessories such as valves are connected by welding to pipes, they are to be provided with necks of sufficient length to prevent abnormal deformations during the execution of welding or heat treatment.

b) For the fixing by welding of branch pipes on pipes, it is necessary to provide either a thickness increase as indicated in 2.2.5 or a reinforcement by doubling plate or equivalent.

3.4 Preparation of elements to be welded and execution of welding

3.4.1 General

Attention is drawn to the provisions of sec 5, which apply to the welding of pressure pipes.

3.4.2 Edge preparation for welded joints

The preparation of the edges is preferably to be carried out by mechanical means. When flame cutting is used, care is to be taken to remove the oxide scales and any notch due to irregular cutting by matching, grinding or chipping back to sound metal.

3.4.3 Abutting of parts to be welded

a) The elements to be welded are to be so abutted that surface misalignments are as small as possible.

b) As a general rule, for elements which are butt-welded without a backing ring the misalignment between internal walls is not to exceed the lesser of:

- the value given in Table 3.1 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.

Table 3.1 : Maximum value of misalignment

d (mm)	t (mm)		
	$t \le 6$	$6 < t \le 10$	$10 < t$
$d < 150$ $150 \le d < 300$ $300 \le d$	1.0 1.0 1.0	1.0 1.5 1.5	1.0 1.5 2.0

3.4.4 Protection against adverse weather conditions

a) Pressure pipes are to be welded, both on board and in the shop, away from draughts and sudden temperature variations.

b) Unless special justification is given, no welding is to be performed if the temperature of the base metal is lower than 0°C.

3.4.5 Preheating

a) Preheating is to be performed as indicated in Table 3.2, depending on the type of steel, the chemical composition and the pipe thickness.

b) The temperatures given in Table 3.2 are based on the use of low hydrogen processes. Where low hydrogen processes are not used, the Society reserves the right to require higher preheating temperatures.

Table 3.2 : Preheating temperature

Type of steel		Thickness of thicker part (mm)	Minimum preheating temperature (°C)
C and C-Mn steels	$C + Mn/6 \le 0.40$	$t \ge 20$ (2)	50
	$C + Mn/6 > 0.40$	$t \ge 20$ (2)	100
0.3 Mo		$t \ge 13$ (2)	100
1 Cr 0.5 Mo		$t < 13$ $t \ge 13$	100 150
2.25 Cr 1 Mo (1)		$t < 13$ $t \ge 13$	150 200
0.5 Cr 0.5 Mo V (1)		$t < 13$ $t \ge 13$	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 the Society.

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

3.5 Post-weld heat treatment

3.5.1 General

a) As far as practicable, the heat treatment is to be carried out in a furnace. Where this is impracticable, and more particularly in the case of welding on board, the treatment is to be performed locally by heating uniformly a circular strip, extending on at least 75 mm on both sides of the welded joint; all precautions are to be taken to permit accurate checking of the temperature and slow cooling after treatment.

b) For austenitic and austenitic ferritic steels, post-weld head treatment is generally not required.

3.5.2 Heat treatment after welding other than oxyacetylene welding

a) Stress relieving heat treatment after welding other than oxyacetylene welding is to be performed as indicated in Table 3.3, 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 Table 3.3, 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 (TT −20)°C, where TT 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 Table 3.4, 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 c).

b) The examination mainly concerns those parts to be welded further to their preparation, the welded joints once they have been made and the conditions for carrying out possible heat treatments.

c) The required examinations are to be carried out by qualified operators in accordance with procedures and techniques to the Surveyor’s satisfaction.

3.6.2 Visual examination

Welded joints, including the inside wherever possible, are to be visually examined.

3.6.3 Non-destructive examinations

Non-destructive tests required are given in:

• Table 3.5 for class I pipes

• Table 3.6 for class II pipes.

Table 3.3: Heat treatment temperature

Type of steel	Thickness of thicker part (mm)	Stress relief treatment temperature (°C)
C and C-Mn steels	$t \geq 15$ (1) (3)	550 to 620
0.3 Mo	$t \geq 15$ (1)	580 to 640
1 Cr 0.5 Mo	$t \geq 8$	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 the Society.

(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 the Society.

Table 3.4: Heat treatment after oxyacetylene welding

Type of steel	Heat treatment and temperature (°C)
C and C-Mn	Normalizing 880 to 940
0.3 Mo	Normalizing 900 to 940
1Cr-0.5Mo	Normalizing 900 to 960 Tempering 640 to 720
2.25Cr-1Mo	Normalizing 900 to 960 Tempering 650 to 780
0.5Cr-0.5 Mo-0.25V	Normalizing 930 to 980 Tempering 670 to 720

Table 3.5: Class I pipe - Type of welded joints

Class I pipe outer diameter D	Butt welded joint	Fillet weld for flange connection	Other welded joint which cannot be radiographed
Frequency of testing	every weld for D > 75mm minimum 10% of welds selected in agreement with the Surveyor for D ≤75 mm	every weld for D > 75mm minimum 10% of welds selected in agreement with the Surveyor for D≤75 mm	every weld for D > 75mm minimum 10% of welds selected in agreement with the Surveyor for D≤75 mm
Extent of testing	full length	full length	full length
Type of testing	radiographic or equivalent accepted by the Society	magnetic particle or liquid penetrant	magnetic particle or liquid penetrant

Table 3.6: Class II pipe - Type of welded joints

Class II pipe outer diameter D	Butt welded joint	Fillet weld for flange connection	Other welded joint which cannot be radiographed
Frequency of testing	minimum 10% of welds selected in agreement with the Surveyor for D >100 mm	minimum 10% of welds selected in agreement with the Surveyor for D >100 mm	minimum 10% of welds selected in agreement with the Surveyor for D>100 mm
Extent of testing	full length	full length	full length
Type of testing	radiographic or equivalent accepted by the Society	magnetic particle or liquid penetrant	magnetic particle or liquid penetrant

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) Acceptance criteria and repairs

- Indications evaluated to be crack, lack of fusion or lack of penetration for class I pipes are not acceptable.

Indications evaluated to be crack or lack of fusion in welds for class II pipes are not acceptable.

Other types of imperfection are to be assessed in accordance with a recognised standard accepted by the Society.

- Unacceptable indications are to be eliminated and repaired where necessary. The repair welds are to be examined on their full length using magnetic particle or liquid penetrant test and ultrasonic or radiographic testing.

When unacceptable indications are found, additional area of the same weld length are to be examined unless the indication is judged isolated without any doubt. In case of automatic welded joints, additional NDE is to be extended to all areas of the same weld length.

The extent of examination can be increased at the surveyor's discretion when repeated non-acceptable indications are found.

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 C-Mo-V steels, a subsequent stress relieving heat treatment in accordance with Table 3.3 is required.

b) After hot bending performed outside the temperature range specified in 4.2.4, a subsequent new heat treatment in accordance with Table 3.4 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 Table 3.4 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 ship.

5.2 Location of tanks and piping system components

5.2.1 Flammable oil systems

Location of tanks and piping system components conveying flammable fluids under pressure is to comply with 5.10.

5.2.2 Piping systems with open ends

Attention is to be paid to the requirements for the location of open-ended pipes on board ships having to comply with the provisions of 5.5.

5.2.3 Pipe lines located inside tanks

a) The passage of pipes through tanks, when permitted, 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 2.4.3.

5.2.4 Overboard discharges

a) All discharges in the shell plating below the freeboard deck shall be fitted with efficient and accessible arrangements for preventing the accidental admission of water into the ship.

b) In manned machinery spaces, the valves may be controlled locally and shall be provided with indicators showing whether they are open or closed. For control of discharge valves fitted below the waterline, see 5.5.4.

c) Overboard discharges are to be so located as to prevent any discharge of water into the lifeboats while they are being lowered.

5.2.5 Piping and electrical apparatus

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.

5.3 Passage through bulkheads or decks

5.3.1 General

For ships other than cargo ships, see also the additional requirements for the relevant service notations.

5.3.2 Penetration of watertight bulkheads or decks and fire divisions

a) Where penetrations of watertight bulkheads or decks and fire divisions are necessary for piping and ventilation, arrangements are to be made to maintain the watertight integrity and fire integrity.

Note 1: In cargo ships, the Society may permit relaxation in the watertightness of opening above the freeboard deck, provided that it is demonstrated that any progressive flooding can be easily controlled and that the safety of the ship is not impaired

b) Lead or other heat sensitive materials are not to be used in piping systems which penetrate watertight subdivision bulkheads or decks, where deterioration of such systems in the event of fire would impair the watertight integrity of the bulkhead or decks.

This applies in particular to the following systems:

- bilge system
- ballast system
- scuppers and sanitary discharge systems.

c) Where bolted connections are used when passing through watertight bulkheads or decks, the bolts are not to be screwed through the plating. Where welded connections are used, they are to be welded on both sides of the bulkhead or deck.

d) Penetrations of watertight bulkheads or decks and fire divisions by plastic pipes are to comply with App 1, 3.6.2.

5.3.3 Passage through the collision bulkhead

a) Except as provided in b) the collision bulkhead may be pierced below the bulkhead deck by not more than one pipe for dealing with fluid in the forepeak tank, provided that the pipe is fitted with a screw-down valve capable of being operated from above the bulkhead deck, the valve chest being secured inside the forepeak to the collision bulkhead. the Society may, however, authorize the fitting of this valve on the after side of the collision bulkhead provided that the valve is readily accessible under all service conditions and the space in which it is located is not a cargo space. All valves shall be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable.

b) If the forepeak is divided to hold two different kinds of liquids the Society may allow the collision bulkhead to be pierced below the bulkhead by two pipes, each of which is fitted as required by a), provided the Society is satisfied that there is no practical alternative to the fitting of such a second pipe and that, having regard to the additional subdivision provided in the forepeak, the safety of the ship is maintained c) The remote operation device of the valve referred to in a) is to include an indicator to show whether the valve is open or shut.

5.4 Independence of lines

5.4.1 As a general rule, bilge and ballast lines are to be entirely independent and distinct from lines conveying liquid cargo, lubricating oil and fuel oil, with the exception of:

- pipes located between collecting boxes and pump suctions
- pipes located between pumps and overboard discharges
- pipes supplying compartments likely to be used alternatively for ballast, fuel oil or liquid or dry cargoes, provided such pipes are fitted with blind flanges or other appropriate change-over devices, in order to avoid any mishandling.

5.5 Prevention of progressive flooding

5.5.1 Principle

a) In order to comply with the subdivision and damage stability requirements of Part 3, Ch 3, Sec 3 provision is to be made to prevent any progressive flooding of a dry compartment served by any open-ended pipe, in the event that such pipe is damaged or broken in any other compartment by collision or grounding.

b) For this purpose, if pipes are situated within assumed flooded compartments, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage. However, the Society may permit minor progressive flooding if it is demonstrated that its effects can be easily controlled and the safety of the ship is not impaired. Refer to Part 3, Ch 3, Sec. 3.

5.5.2 Extent of damage

For the definition of the assumed transverse extent of damage, reference is to be made to Part 3, Ch 3, Sec 3.

5.5.3 Piping arrangement

a) The assumed transverse extent of damage is not to contain any pipe with an open end in a compartment located outside this extent, except where the section of such pipe does not exceed 710 mm^2.

Note 1: Where several pipes are considered, the limit of 710 mm^2 applies to their total section.

b) Where the provisions of item a) cannot be fulfilled, and after special examination by the Society, pipes may be situated within the assumed transverse extent of damage penetration provided that:

- either a closable valve operable from above the bulkhead deck is fitted at each penetration of a watertight subdivision and secured directly on the bulkhead, or
- a closable valve operable from above the bulkhead deck is fitted at each end of the pipe concerned, the valves and their control system being inboard of the assumed extent of damage, or
- the tanks to which the pipe concerned leads are regarded in the damage stability calculations as being flooded when damage occurs in a compartment through which the pipe passes.

c) Valves required to be operable from above the bulkhead deck are to be fitted with an indicator to show whether the valve is open or shut.

Where the valve is remote controlled by other than mechanical means, and where the remote control system is located, even partly, within the assumed extent of damage penetration, this system is to be such that the valve is automatically closed by loss of power.

d) Air and overflow pipes are to be so arranged as to prevent the possibility of flooding of other tanks in other watertight compartments in the event of any one tank being flooded.

This arrangement is to be such that in the range of positive residual righting levers beyond the angle of equilibrium stage of flooding, the progressive flooding of tanks or watertight compartments other than that flooded does not occur.

5.5.4 Suction and discharge valves below the waterline

a) The location of controls of any valve serving a sea inlet, a discharge below the waterline or a bilge injection system is to comply with Rules requirements.

b) The National Authority of the country in which the ship is to be registered may have different criteria.

5.6 Provision for expansion

5.6.1 General

Piping systems are to be so designed and pipes so fixed as to allow for relative movement between pipes and the ship’s structure, having due regard to the:

- temperature of the fluid conveyed
- coefficient of thermal expansion of the pipes material
- deformation of the ship’s hull.

5.6.2 Fitting of expansion devices

All pipes subject to thermal expansion and those which, due to their length, may be affected by deformation of the hull, are to be fitted with expansion pieces or loops.

5.7 Supporting of the pipes

5.7.1 General

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

5.7.2 Arrangement of supports

Shipyards are to take care that:

a) The arrangement of supports and collars is to be such that pipes and flanges are not subjected to abnormal bending stresses, taking into account their own mass, the metal they are made of, and the nature and characteristics of the fluid they convey, as well as the contractions and expansions to which they are subjected.

b) Heavy components in the piping system, such as valves, are to be independently supported.

5.8 Protection of pipes

5.8.1 Protection against shocks

Pipes passing through cargo holds and 'tweendecks are to be protected against shocks by means of strong casings.

5.8.2 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 galvanizing 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 galvanized steel pipes are used for sea water systems, the water velocity is not to exceed 3 m/s.

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

e) Arrangements are to be made to avoid galvanic corrosion

f) If aluminum bras pipes are used for sea water systems, the water velocity is not to exceed 3 m/s

g) If 90/10 copper-nickel-iron pipes are used for sea water systems, the water velocity is not to exceed 3,5 m/s

h) If 70/30 copper-nickel pipes are used for sea water systems, the water velocity is not to exceed 5 m/s

i) If GRP pipes are used for sea water systems, the water velocity is not to exceed 5 m/s.

5.8.3 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.

5.8.4 Protection of high temperature pipes and components

a) All pipes and other components where the temperature may exceed 220°C are to be efficiently insulated. Where necessary, precautions are to be taken to protect the insulation from being impregnated with flammable oils.

b) Particular attention is to be paid to lagging in way of flanges.

5.9 Valves, accessories and fittings

5.9.1 General

Cocks, valves and other accessories are generally to be arranged so that they are easily visible and accessible for maneuvering, control and maintenance. They are to be installed in such a way as to operate properly.

5.9.2 Valves and accessories

a) In machinery spaces and tunnels, the cocks, valves and other accessories of the fluid lines referred to in this Section are to be placed:

- above the floor, or
- when this is not possible, immediately under the floor, provided provision is made for their easy access and control in service.

b) Control-wheels of low inlet valves are to rise at least 0,45 m above the lowest floor.

5.9.3 Flexible hoses and expansion joints

a) Flexible hoses and expansion joints are to be in compliance with 2.6. They are to be installed in clearly visible and readily accessible locations.

b) The number of flexible hoses and expansion joints is to be kept to minimum and limited for the purpose stated in 2.6.1, item c).

c) 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.

d) The installation of a flexible hose assembly or an expansion joint is to be in accordance with the manufacturer's instructions and use limitations, with particular attention to the following:

- orientation
- end connection support (where necessary)
- avoidance of hose contact that could cause rubbing and abrasion
- minimum bend radii.

e) Flexible hose assemblies or expansion joints are not to be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions.

f) Where flexible hoses or an expansion joint are intended to be used in piping systems conveying flammable fluids that are in close proximity of 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) The adjoining pipes are to be suitably aligned, supported, guided and anchored.

h) Isolating valves are to be provided permitting the isolation of flexible hoses intended to convey flammable oil or compressed air.

i) Expansion joints are to be protected against over extension or over compression.

j) Where they are likely to suffer external damage, flexible hoses and expansion joints of the bellows type are to be provided with adequate protection.

5.9.4 Thermometers

Thermometers and other temperature-detecting elements in fluid systems under pressure are to be provided with pockets built and secured so that the thermometers and detecting elements can be removed while keeping the piping under pressure.

5.9.5 Pressure gauges

Pressure gauges and other similar instruments are to be fitted with an isolating valve or cock at the connection with the main pipe.

5.9.6 Nameplates

a) Accessories such as cocks and valves on the fluid lines referred to in this Section are to be provided with nameplates indicating the apparatus and lines they serve except where, due to their location on board, there is no doubt as to their purpose.

b) Nameplates are to be fitted at the upper part of air and sounding pipes.

5.10 Additional arrangements for flammable fluids

5.10.1 General

All necessary precautions are to be taken to reduce fire risks from flammable liquids, such as:

- drips
- leaks under pressure
- overflow
- hydrocarbon accumulation in particular under lower floors
- discharges of oil vapours during heating
- soot or unburnt residue in smoke stacks or exhaust pipes.
- Unless otherwise specified, the requirements in 5.10.3 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.

5.10.2 Prohibition of carriage of flammable oils in forepeak tanks

In cargo ships of more than 400 tons gross tonnage and in passenger ships, fuel oil, lubricating oil and other flammable oils are not to be carried in forepeak tanks or tanks forward of the collision bulkhead.

5.10.3 Prevention of flammable oil leakage ignition

a) As far as practicable, the piping arrangement in the flammable oil systems shall comply generally with the following:

- The conveying of flammable oils through accommodation and service spaces is to be avoided. Where it is not possible, the arrangement may be subject to special consideration by the Society, provided that the pipes are of a material approved having regard to the fire risk.
- The pipes are not to be located immediately above or close to the hot surfaces (exhaust manifolds, silencers, steam pipelines, boilers, etc.), electrical installations or other sources of ignition. Otherwise, suitably protection (screening and effective drainage to the safe position) is to be provided to prevent of spraying or leakage onto the sources of ignition.
- Parts of the piping systems conveying heated flammable oils 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 there from can constitute a hazard by falling on:

- hot surfaces, including those of boilers, heaters, steam pipes, 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) Pipe connections, expansion joints and flexible parts of flammable oil lines are to be screened or otherwise suitably protected to avoid, as far as practicable, oil spray or oil leakages onto hot surfaces, into machinery air intakes, or on other sources of ignition.

The fastening of connections (nuts, screws, etc.) of lubricating oil or fuel oil pipes above 1,8 bar pressure is to be locked.

e) Any relief valve or air vent cock fitted within the flammable liquid systems is to discharge to a safe position, such as an appropriate tank.

f) Appropriate means are to be provided to prevent undue opening (due to vibrations) of air venting cocks fitted on equipment or piping containing flammable liquid under pressure.

5.10.4 Provisions for flammable oil leakage containment

a) Tanks used for the storage of flammable oils together with their fittings are to be so arranged as to prevent spillages due to leakage or overfilling.

b) Drip trays with adequate drainage to contain possible leakage from flammable fluid systems are to be fitted:

- under independent tanks
- under burners

- under purifiers and any other oil processing equipment
- under pumps, heat exchangers and filters
- under valves and all accessories subject to oil leakage
- surrounding internal combustion engines.

c) The coaming height of drip trays is to be appropriate for the service and not less than 75 mm.

d) Where boilers are located in machinery spaces on tweendecks and the boiler rooms are not separated from the machinery spaces by watertight bulkheads, the tweendecks are to be provided with oil-tight coamings at least 200 mm in height.

e) Where drain pipes are provided for collecting leakages, they are to be led to an appropriate drain tank.

f) The draining system of the room where thermal fluid heaters are fitted, as well as the save all of the latter, are not to allow any fire extension outside this room. See also 13.3.2.

5.10.5 Drain tank

a) The drain tank is not to form part of an overflow system and is to be fitted with an overflow alarm device.

b) In ships required to be fitted with a double bottom, appropriate precautions are to be taken when the drain tank is constructed in the double bottom, in order to avoid flooding of the machinery space where drip trays are located, in the event of accidentally running aground.

5.10.6 Valves

All valves and cocks forming part of flammable oil systems are to be capable of being operated from readily accessible positions and, in machinery spaces, from above the working platform.

5.10.7 Level switches

Level switches fitted to flammable oil tanks are to be contained in a steel or other fire-resisting enclosure.

6 Bilge systems

6.1 Application

6.1.1 This Article does not apply to bilge systems of nonpropelled ships.

6.2 Principle

6.2.1 General

An efficient bilge pumping system shall be provided, capable of pumping from and draining any watertight compartment other than a space permanently appropriated for the carriage of fresh water, water ballast, fuel oil or liquid cargo and for which other efficient means of pumping are to be provided, under all practical conditions. Efficient means shall be provided for draining water from insulated holds. Bilge pumping system is not intended at coping with water ingress resulting from structural or main sea water piping damage.

6.2.2 Availability of the bilge system

The bilge system is to be able to work while the other essential installations of the ship, especially the fire-fighting installations, are in service.

6.2.3 Bilge and ballast systems

The arrangement of the bilge and ballast pumping system shall be such as to prevent the possibility of water passing from the sea and from water ballast spaces into the cargo and machinery spaces, or from one compartment to another.

Provisions shall be made to prevent any deep tank having bilge and ballast connections being inadvertently flooded from the sea when containing cargo, or being discharged through a bilge pump when containing water ballast.

6.3 Design of bilge systems

6.3.1 General

a) The bilge pumping system is to consist of pumps connected to a bilge main line so arranged as to allow the draining of all spaces mentioned in 6.2.1 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 6.6.3 and 6.6.4.

b) If deemed acceptable by the Society, bilge pumping arrangements may be dispensed with in specific compartments provided the safety of the ship is not impaired.

6.3.2 Number and distribution of bilge suctions

a) Draining of watertight spaces is to be possible, when the ship is on an even keel and either is upright or has a list of up to 5°, by means of at least:

- two suctions in machinery spaces, including one branch bilge suction and one direct suction and, in addition, for spaces containing propulsion machinery, one emergency bilge suction
- one suction in other spaces. See also 6.5.5.

b) Bilge suctions are to be arranged as follows:

- wing suctions are generally to be provided except in the case of short and narrow compartments when a single suction ensures effective draining in the above conditions
- in the case of compartments of unusual form, additional suctions may be required to ensure effective draining under the conditions mentioned in 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.

6.3.3 Prevention of communication between spaces Independence of the lines

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

b) Bilge lines are to be entirely independent and distinct from other lines except where permitted in 5.4.

c) In ships designed for the carriage of flammable or toxic liquids in enclosed cargo spaces, the bilge pumping system is to be designed to prevent the inadvertent pumping of such liquids through machinery space piping or pumps.

6.4 Draining of cargo spaces

6.4.1 General

a) Cargo holds are to be fitted with bilge suctions connected to the bilge main.

b) Drainage arrangements for cargo holds likely to be used alternatively for ballast, fuel oil or liquid or dry cargoes are to comply with 7.1.

c) Drainage of enclosed cargo spaces situated on the freeboard deck of a cargo ship and on the bulkhead deck of a passenger ship shall comply with 8.5.

d) Drainage of enclosed cargo spaces intended to carry dangerous goods shall be provided in accordance with rules requirements.

6.4.2 Ships without double bottom

a) In ships without double bottom, bilge suctions are to be provided in the holds:

- at the aft end in the centreline where the rise of floor exceeds 5°
- at the aft end on each side in other cases.

b) Additional suctions may be required if, due to the particular shape of the floor, the water within the compartment cannot be entirely drained by means of the suctions mentioned in a) above.

6.4.3 Ships with double bottom

a) In ships with double bottom, bilge suctions are to be provided in the holds on each side aft. Where the double bottom plating extends from side to side, the bilge suctions are to be led to wells located at the wings.

Where the double bottom plating slopes down to the centreline by more than 5°, a centreline well with a suction is also to be provided.

b) If the inner bottom is of a particular design, shows discontinuity or is provided with longitudinal wells, the number and position of bilge suctions will be given special consideration by the Society.

6.4.4 Ships with holds over 30 m in length

In holds greater than 30 m in length, bilge suctions are to be provided in the fore and aft ends.

6.4.5 Additional suctions

Additional suctions may be required in the forward part of holds in ships which are likely to navigate normally with a trim by the head.

6.4.6 Drainage of cargo spaces, other than ro-ro spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion

In cargo spaces, other than ro-ro spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion and fitted with a fixed pressure water-spraying fire-extinguishing system, the pumping arrangement is to be such as to prevent the build-up of free surfaces. If this is not possible, the adverse effect upon stability of the added weight and free surface of water is to be taken into account to the extent deemed necessary by the Society in its approval of the stability information. See Part 3, Chapter 3.

6.4.7 Drainage of cargo spaces intended for the carriage of flammable or toxic liquids

In ships designed for the carriage of flammable or toxic liquids in enclosed cargo spaces, and where large quantities of such liquids are carried, consideration is to be given to the provision of additional means of draining such spaces.

6.5 Draining of machinery spaces

6.5.1 General

Where all the propulsion machinery, boilers 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 6.5.5.

6.5.2 Branch bilge suction

The branch bilge suction is to be connected to the bilge main.

6.5.3 Direct suction

The direct suction is to be led direct to an independent power bilge pump and so arranged that it can be used independently of the main bilge line.

The use of ejectors for pumping through the direct suction will be given special consideration.

6.5.4 Emergency bilge suction

a) The emergency bilge suction is to be led directly from the drainage level of the machinery space to a main circulating (or cooling) pump and fitted with a non-return valve.

b) In ships where, in the opinion of the Society, the main circulating (or cooling) pump is not suitable for this purpose, the emergency bilge suction is to be led from the largest available independent power driven pump to the drainage level of the machinery space. Such a pump is not to be a bilge pump. Its capacity when the emergency suction is operating is to be at least equal to the required capacity of each bilge pump as determined in 6.7.4.

c) The emergency bilge suction is to be located at the lowest possible level in the machinery spaces.

6.5.5 Number and distribution of suctions in propulsion machinery spaces

a) In propulsion machinery spaces, bilge suctions are to include:

- where the bottom of the space, bottom plating or top of the double bottom slope down to the centerline 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 and in all passenger ships, at least two suctions, i.e. one branch bilge suction and one direct suction, on each side, and • one emergency bilge suction.

b) If the tank top is of a particular design or shows discontinuity, additional suctions may be required.

c) Where the propulsion machinery space is located aft, suctions are normally to be provided on each side at the fore end and, except where not practicable due to the shape of the space, on each side at the aft end of the space.

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

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

In boiler and auxiliary compartments, bilge suctions are to include:

- bilge branch suctions distributed as required in 6.4.2 to 6.4.5 for cargo holds
- one direct suction.

6.6 Draining of dry spaces other than cargo holds and machinery spaces

6.6.1 General

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

b) Draining arrangements of tanks are to comply with the provisions of 7.

6.6.2 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.

6.6.3 Draining of fore and aft peaks

a) Where the peaks are not used as tanks and bilge suctions are not fitted, drainage of both peaks may be effected by hand pump suction provided that the suction lift is well within the capacity of the pump and in no case exceeds 7.3 m.

b) Except where permitted in 5.3.3, the collision bulkhead is not to be pierced below the freeboard deck.

c) For tankers, refer to Part 5, Ch 5.

d) For ships intended primarily to carry dry cargo in bulk, see 6.6.7.

6.6.4 Draining of spaces above fore and aft peaks

a) Provision is to be made for the drainage of the chain lockers and watertight compartments above the fore peak tank by hand or power pump suctions.

b) Steering gear compartments or other small enclosed spaces situated above the aft peak tank are to be provided with suitable means of drainage, either by hand or power pump bilge suctions. However, in the case of rudder stock glands located below the summer load line, the bilge suctions of the steering gear compartment are to be connected to the main bilge system.

c) If the compartments referred to in b) are adequately isolated from the adjacent tweendecks, they may be drained by scuppers discharging to the tunnel (or machinery space in the case of ships with machinery aft) and fitted with self-closing cocks situated in well lighted and visible positions.

Note 1: This arrangement is not applicable to ships required to comply with 5.5, and in particular to passenger ships, unless they are specially approved in relation to subdivision.

d) For ships intended primarily to carry dry cargo in bulk, see 6.6.7.

6.6.5 Draining of tunnels

a) Tunnels are to be drained by means of suctions connected to the main bilge system. Such suctions are generally to be located in wells at the aft end of the tunnels.

b) Where the top of the double bottom, in the tunnel, slopes down from aft to forward, an additional suction is to be provided at the forward end of this space.

6.6.6 Draining of refrigerated spaces

Provision is to be made for the continuous drainage of condensate in refrigerated and air cooler spaces. To this end, valves capable of blanking off the water draining lines of such spaces are not to be fitted, unless they are operable from an easily accessible place located above the load waterline.

6.6.7 Specific requirements for drainage of forward spaces of bulk, ore and combination carriers ("dewatering system")

Unless otherwise specified, this requirement applies to ships with service notation bulk carrier, ore carrier or combination carrier, as described in Part I.

a) The bilge of dry spaces any part of which extends forward of the foremost cargo hold, as well as the means for draining and pumping ballast tanks forward of the collision bulkhead, is to be capable of being brought into operation from a readily accessible enclosed space, the location of which is accessible from the navigation bridge or propulsion machinery control position without traversing exposed freeboard or superstructure decks.

The following criteria are to govern the application of the requirement:

- a position which is accessible via an under deck passage, a pipe trunk or other similar means of access is not to be taken as being in the accessible enclosed space.
- the requirement does not apply to the enclosed spaces the volume of which does not exceed 0.1% of the ship maximum displacement volume and to the chain locker.

b) The water level detectors, giving an audible and visual alarm located on the navigation bridge, are to be fitted:

- in any ballast tank forward of the collision bulkhead, indicating when the liquid in the tank reaches a level not exceeding 10% of the tank capacity. An alarm overriding device may be installed to be activated when the tank is in use.
- in any dry or void space which is to comply with the requirements in item a), giving the alarm at a water level of 0.1 m above the deck.

c) The capacity of the dewatering system is to be designed to remove water from the forward spaces at a rate of not less than (320 A) m^3/h, where A is the cross-sectional area, in m2, of the largest air pipe or ventilator pipe connected from the exposed deck to a closed forward space that is required to be dewatered by these arrangements.

d) When dewatering systems are in operation, the following is to be fulfilled:

- other systems essential for the safety of the ship, including fire-fighting and bilge systems, are to remain available and ready for immediate use
- it is to be possible to start fire pumps immediately and to have a ready available supply of fire-fighting water
- the systems for normal operation of electric power supplies, propulsion and steering are not to be affected by this operation.

e) The drainage arrangements are to be such that:

- any accumulated water can be drained directly by a pump or an eductor
- it may be possible to configure and use bilge system for any compartment when the drainage system is in operation
- remotely operated valves within the system comply with 2.7.3
- bilge wells are protected by gratings or strainers to prevent blockage of the drainage system with debris.

f) Where pipes serving such tanks or bilge pierce the collision bulkhead, valve operation by means of remotely operated actuators may be accepted as an alternative to the valve control required in 5.3.3, provided that the location of such valve controls complies with 5.3.3.

For that purpose, the following is to be fulfilled:

- the valve required in 5.3.3 is to be capable of being controlled from the position as required in item a)
- the valve is not to move from the demanded position in the case of failure of the control system power or actuator power
- positive indication is to be provided at the remote control station to show that the valve is fully open or closed
- in addition, the local hand powered valve operation from above the freeboard deck is also to be provided.

g) The piping arrangements for drainage of closed dry spaces may be connected to the piping arrangements for drainage of water ballast tanks, provided that:

- two non-return valves are provided to prevent the ingress of water into dry spaces from those intended for the carriage of water ballast
- the non-return valves are located in readily accessible positions
- one of these non-return valves is fitted with shut-off isolation arrangement
- the shut-off isolation arrangement is capable of being controlled from the position as required in item a).

6.7 Bilge pumps

6.7.1 Number and arrangement of pumps

a) For cargo ships, at least two power pumps connected to the main bilge system are to be provided, one of which may be driven by the propulsion machinery.

b) Additional requirements for passenger ships are given in Part 5 .

c) Each pump may be replaced by a group of pumps connected to the bilge main, provided their total capacity meets the requirements specified in 6.7.4.

d) Alternative arrangements, such as the use of a hand pump in lieu of a power pump, will be given special consideration by the Society.

6.7.2 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.

On passenger ships, the pump supplying the ejector is not to be used for other services.

6.7.3 Use of other pumps for bilge duties

a) Other pumps may be used for bilge duties, such as fire, general service, sanitary service or ballast pumps, provided that:

- they meet the capacity requirements
- suitable piping arrangements are made
- pumps are available for bilge duty when necessary.

b) The use of bilge pumps for fire duty is to comply with the provisions of Chapter 4.

6.7.4 Capacity of the pumps

a) Each power bilge pump is to be capable of pumping water through the required main bilge pipe at a speed of not less than 2 m/s.

b) The capacity of each pump or group of pumps is not to be less than:

$Q = 0.00565\ d^2$

where:

Q : Minimum capacity of each pump or group of pumps, in m^3/h

d : Internal diameter, in mm, of the bilge main as defined in 6.8.1.

Note 1: For cargo ships of less than 35 m in length:

- the speed of water to be considered for calculating the capacity may be reduced to 1.22 m/s
- the capacity of each pump or group of pumps is not to be less than $Q = 0.00345\ d^2$.

c) If the capacity of one of the pumps or one of the groups of pumps is less than the Rule capacity, the deficiency may be compensated by an excess capacity of the other pump or group of pumps; as a rule, such deficiency is not permitted to exceed 30% of the Rule capacity.

Note 2: This provision does not apply to passenger ships.

d) The capacity of hand pumps is to be based on one movement once a second.

e) 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.

6.7.5 Choice of the pumps

a) Bilge pumps are to be of the self-priming type. Centrifugal pumps are to be fitted with efficient priming means, unless an approved priming system is provided to ensure the priming of pumps under normal operating conditions.

b) Circulating or cooling water pumps connected to an emergency bilge suction need not be of the self-priming type.

c) Sanitary, ballast and general service pumps may be accepted as independent power bilge pumps if fitted with the necessary connections to the bilge pumping system.

d) Hand pumps are to have a maximum suction height not exceeding 7.30 m and to be operable from a position located above the load waterline.

6.7.6 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.

6.7.7 Electrical supply of submersible pump motors

a) Where submersible bilge pumps are provided, arrangements are to be made to start their motors from a convenient position above the bulkhead deck.

b) Where an additional local-starting device is provided at the motor of a permanently installed submersible bilge pump, the circuit is to be arranged to provide for the disconnection of all control wires therefrom at a position adjacent to the starter installed on the deck.

6.8 Size of bilge pipes

6.8.1 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 : Internal diameter of the bilge main, in mm

L and B : Length and breadth of the ship as defined in Part 1, in m

D : Moulded depth of the ship to the bulkhead deck, in m, provided that, in a ship having an enclosed cargo space on the bulkhead deck which is internally drained in accordance with the requirements of 8.5.3 and which extends for the full length of the ship, D is measured to the next deck above the bulkhead deck. Where the enclosed cargo spaces cover a lesser length, D is to be taken as the moulded depth to the bulkhead deck plus *lh/L* where *l* and *h* are the aggregate length and height, respectively, of the enclosed cargo spaces, in m.

Note 1: In cargo ships fitted with side ballast tanks forming a double hull on the whole length of the holds, the diameter of the bilge main may be determined by introducing the actual breadth of the holds amidships as B in the above formula. For the part of bilge main serving the suctions to machinery spaces, the cross-section is not to be less than twice the cross-sections resulting from 6.8.3 for branch bilge suctions to those machinery spaces and need not exceed that of the bilge main resulting from the above formula.

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 60 mm, or
- less than that obtained from the formula given in 6.8.3 for branch bilge suctions.

c) For tankers, the internal diameter d of the bilge main in engine room shall be determined in accordance with the rules requirements.

d) For cargo ships where L < 20 m and assigned with a restricted navigation notation, as well as for sailing ships with or without auxiliary engine, the bilge system will be specially considered by the Society in each particular case.

6.8.2 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.

6.8.3 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:

$$d_1 = 25 + 2.16\sqrt{L_1\left(B + D\right)}$$

where:

B and D : as defined in 6.8.1

L_1 : Length of the compartment, in m.

d_1 is not to be less than 50 mm and need not exceed 100 mm.

b) For ships other than passenger ships, which have side ballast tanks forming a double hull, the diameter of suction pipes in holds may be determined by introducing as B the actual breadth of the holds amidships.

6.8.4 Direct suctions other than emergency suctions

a) Direct suctions are to be suitably arranged and those in a machinery space are to be of a diameter not less than that required for the bilge main.

b) In cargo ships having separate machinery spaces of small dimensions, the size of the direct suctions need not exceed that given in 6.8.3 for branch bilge suctions.

6.8.5 Emergency suctions in machinery spaces

a) The diameter of emergency bilge suction pipes is to be:

- at least two thirds of the diameter of the pump inlet in the case of steamships
- the same as the diameter of the pump inlet in the case of motorships.

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.

6.8.6 Bilge suctions from tunnels

Bilge suction pipes to tunnel wells are not to be less than 65 mm in diameter. In ships up to 60 metres in length, this diameter may be reduced to 50 mm.

6.8.7 Scuppers in aft spaces

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

6.8.8 Bilge for small ships

For cargo ships of a length L, as defined in 6.8.1, less than 20 m and assigned with a restricted navigation notation, as well as for sailing ships with or without auxiliary engine, the bilge system will be specially considered by the Society in each single case.

6.8.9 Bilge main for tankers

In tankers and other ships where the bilge pumps are designed to pump from the machinery space only, the internal diameter d, in mm, of the bilge main may be less than that required by the formula in 6.8.1 above, but it is to be not less than that obtained from the value specified by the rules.

6.9 Bilge accessories

6.9.1 Drain valves on watertight bulkheads

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

b) On other watertight bulkheads, the fitting of drain valves or similar devices is allowed unless practical alternative draining means exist. Such valves are to be easily accessible at all times and operable from above the freeboard deck. Means indicating whether the valves are open or closed are to be provided.

6.9.2 Screw-down non-return valves

a) Accessories are to be provided to prevent intercommunication of compartments or lines which are to remain segregated from one another. For this purpose, nonreturn devices are to be fitted:

- on the pipe connections to bilge distribution boxes or to the alternative valves, if any
- on direct and emergency suctions in machinery spaces
- on the suctions of pumps which also have connections from the sea or from compartments normally intended to contain liquid
- on flexible bilge hose connections
- on the suctions of water bilge ejectors
- at the open end of bilge pipes passing through deep tanks
- in compliance with the provisions for the prevention of progressive flooding, if applicable.

b) Screw-down and other non-return valves are to be of a recognized type which does not offer undue obstruction to the flow of water.

6.9.3 Mud boxes

In machinery spaces and shaft tunnels, 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.

6.9.4 Strum boxes

a) In compartments other than machinery spaces and shaft tunnels, the open ends of bilge suction pipes are to be fitted with strum boxes or strainers having holes not more than 10 mm in diameter. The total area of such holes is to be not less than twice the required cross-sectional area of the suction pipe.

b) Strum boxes are to be so designed that they can be cleaned without having to remove any joint of the suction pipe.

6.9.5 Bilge wells

a) The wells provided for draining the various compartments are to be of a capacity not less than 0.15 m^3. In small compartments, smaller cylindrical wells may be fitted.

b) Bilge wells are to comply with the relevant provisions of Part 3.

6.9.6 Liquid sealed traps

a) The bilge line of refrigerated spaces is to be provided with liquid sealed traps of adequate size arranged for easy cleaning and refilling with brine. These traps are to be fitted with removable grids intended to hold back waste products when defrosting.

b) Where drain pipes from separate refrigerated rooms join a common main, each of these pipes is to be provided with a liquid sealed trap.

c) As a general rule, liquid sealed traps are to be fitted with non-return valves. However, for refrigerated spaces not situated in the ship bottom, non-return valves may be omitted, provided this arrangement does not impair the integrity of the watertight subdivision.

6.10 Materials

6.10.1 All bilge pipes used in or under coal bunkers or fuel storage tanks or in boiler or machinery spaces, including spaces in which oil-settling tanks or fuel oil pumping units are situated, shall be of steel or other suitable material nonsensitive to heat.

6.11 Bilge piping arrangement

6.11.1 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 Table 2.2 for steel pipes.

6.11.2 Passage through deep tanks

The parts of bilge pipes passing through deep tanks intended to contain water ballast, fresh water, liquid cargo or fuel oil are normally to be contained within pipe tunnels.

Alternatively, such parts are to have reinforced thickness, as per Table 2.2 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.

These pipes are to be provided at their ends in the holds with non-return valves.

6.11.3 Provision for expansion

Where necessary, bilge pipes inside tanks are to be fitted with expansion bends. Sliding joints are not permitted for this purpose.

6.11.4 Connections

Connections used for bilge pipes passing through tanks are to be welded joints or reinforced flange connections.

6.11.5 Access to valves and distribution boxes

All distribution boxes and manually operated valves in connection with the bilge pumping arrangement shall be in positions which are accessible under ordinary circumstances Hand-wheels of valves controlling emergency bilge suctions are to rise at least 0,45 m above the maneuvering floor.

6.12 Water ingress detection

6.12.1 Specific requirements for bulk, ore and combination carriers

Unless otherwise specified, these requirements apply to ships with service notation bulk carrier, bulk carrier ESP, ore carrier ESP, combination carrier/OBO ESP or combination carrier/OOC ESP.

a) Each cargo hold is to be fitted with the water level detectors, giving audible and visual alarms located on the navigation bridge, one when the water level above the inner bottom in any hold reaches a height of 0.5 m and another at a height not less than 15% of the depth of the cargo hold but not more than 2 m.

b) The water level detectors are to be fitted in the aft end of the cargo holds. For cargo holds which are used for water ballast, an alarm overriding device may be installed. The visual alarms are to clearly discriminate between the two different water levels detected in each hold.

c) Relevant documentation and drawings are to be submitted for review, including at least:

- type approval of Water Ingress Detection System, i.e. sensors/detectors wiring and control panel
- general arrangement of sensors and cables
- power supply electrical diagram
- detailed installation drawing of a sensor
- copy of the DOC of compliance for the carriage of dangerous goods and BC Code attestation, if any.

6.12.2 Specific requirements for general cargo ships

Unless otherwise specified, these requirements apply to ships having a length L of less than 80 m and 500 GT and over, with the service notation general cargo ship (see 6.12.2, Note 1), container ship, ro-ro cargo ship (see 6.12.2, Note 2), refrigerated cargo ship, livestock carrier, deck ship (see 6.12.2, Note 2), liquefied gas carrier (of LPG type) (see 6.12.2, Note 2) or supply vessel (see 6.12.2, Note 2).

a) Ships with a single cargo hold below the freeboard deck, or with cargo holds below the freeboard deck which are not separated by at least one bulkhead made watertight up to the freeboard deck, are to be fitted with water level detectors, giving audible and visual alarms located on the navigation bridge, one when the water level above the inner bottom reaches a height of not less than 0.3 m and another at a height not more than 15% of the mean depth of the cargo hold.

b) The water level detectors are to be fitted in the aft end of the cargo hold or above its lowest part where the inner bottom is not parallel to the designed waterline. Where webs or partial watertight bulkheads are fitted above the inner bottom, the Society may require the fitting of additional detectors. The visual alarms are to clearly discriminate between the two different water level detectors in hold.

c) The water level detectors need not to be fitted in ships complying with the requirements in 6.12.1 or in ships having watertight side compartments each side of the cargo hold length extending vertically at least from the inner bottom to the freeboard deck.

d) Relevant documentation and drawings are to be submitted for review, including at least:

- type approval of Water Ingress Detection System, i.e. sensors/detectors wiring and control panel
- general arrangement of sensors and cables
- power supply electrical diagram
- detailed installation drawing of a sensor
- copy of the DOC of compliance for the carriage of dangerous goods and BC Code attestation, if any.

Note 1: The requirements also apply to dedicated cement carriers, dedicated forest product carriers, dedicated woodchip carriers, timber and log carriers, with the same conditions.

Note 2: The scope of application for this type of ships is subject to special consideration.

7 Ballast systems

7.1 Design of ballast systems

7.1.1 Independence of ballast lines

Ballast lines are to be entirely independent and distinct from other lines except where permitted in 5.4.

7.1.2 Prevention of undesirable communication between spaces or with the sea

Ballast systems in connection with bilge systems are to be so designed as to avoid any risk of undesirable communication between spaces or with the sea. See 6.2.3.

7.1.3 Alternative carriage of ballast water or other liquids and dry cargo

Holds and deep tanks designed for the alternative carriage of water ballast, fuel oil or dry cargo are to have their filling and suction lines provided with blind flanges or appropriate change-over devices to prevent any mishandling.

7.2 Ballast pumping arrangement

7.2.1 Filling and suction pipes

a) All tanks including aft and fore peak and double bottom tanks intended for ballast water are to be provided with suitable filling and suction pipes connected to special power driven pumps of adequate capacity.

b) Small tanks used for the carriage of domestic fresh water may be served by hand pumps.

c) Suctions are to be so positioned that the transfer of sea water can be suitably carried out in the normal operating conditions of the ship. In particular, two suctions may be required in long compartments.

d) On bulk carriers, the means for draining and pumping ballast tanks forward of the collision bulkhead are to comply with 6.6.7.

7.2.2 Pumps

At least two power driven ballast pumps are to be provided, one of which may be driven by the propulsion unit. Sanitary and general service pumps may be accepted as independent power ballast pumps.

Bilge pumps may be used for ballast water transfer provided the provisions of 6.7.3 are fulfilled.

Alternative means of deballasting, such as an eductor, may be accepted in lieu of a second ballast pump, subject to special consideration in each particular case.

7.2.3 Passage of ballast pipes through tanks

If not contained in pipe tunnels, the ballast steel pipes passing through tanks intended to contain fresh water, fuel oil or liquid cargo are:

- to have reinforced thickness, as per Table 2.2
- to consist either of a single piece or of several pieces assembled by welding, by reinforced flanges or by devices deemed equivalent for the application considered
- to have a minimal number of joints in these lines
- to have expansion bends in these lines within the tank, where needed
- not to have slip joints.

For ballast lines passing through oil cargo tanks, where permitted, see Part 5, Ch 5.

7.2.4 Ballast valves and piping arrangements

a) Ballast tank valves

Valves controlling flow to ballast tanks are to be arranged so that they remain closed at all times except when ballasting. Where butterfly valves are used, they are to be of a type able to prevent movement of the valve position due to vibration or flow of fluids.

b) Remote control valves

Remote control valves, where fitted, are to be arranged so that they close and remain closed in the event of loss of control power. The valves may remain in the last ordered position upon loss of power, provided that there is a readily accessible manual means to close the valves upon loss of power.

Remote control valves are to be clearly identified as to the tanks they serve and are to be provided with position indicators at the ballast control station.

c) Ballast piping arrangements

For ships which are subject to damage stability, the piping arrangements are to comply with the requirements of 5.5 concerning the prevention of progressive floading.

The pipes, if damaged, which are located within the extent of assumed damage, are not to affect damage stability considerations.

7.3 Requirements on ballast water exchange at sea

7.3.1 General

Unless otherwise specified, this sub-article applies to new ships where ballast water exchange at sea is accepted as a process for the treatment of ballast water.

7.3.2 Definitions

a) A Ballast Water Exchange (BWE) plan contains procedures and advice to safely and efficiently exchange of ballast water in accordance with applicable structural and stability requirements and taking into account the precautions contained in Appendix 2 of IMO Res. A. 868(20).

b) Sequential method - a process by which a ballast tank or hold intended for the carriage of water ballast is emptied of at least 95% or more of its volume and then refilled with replacement ballast water.

c) Flow-through method - a process by which replacement ballast water is pumped into a ballast tank or hold intended for the carriage of water ballast allowing water to flow through overflow or other arrangements. At least three times the tank or hold volume is to be pumped through the tank or hold.

d) Dilution method - a process by which replacement ballast water is filled through the top of the ballast tank or hold intended for the carriage of water ballast with simultaneous discharge from the bottom at the same flow rate and maintaining a constant level in the tank or hold. At least three times the tank or hold volume is to be pumped through the tank or hold.

7.3.3 Ballast water pumping and piping arrangement

a) Ballast water pumping and piping arrangements are to be capable of filling and pumping out any ballast tank and hold intended for the carriage of water ballast under any environmental conditions permitted by the Ballast Water Exchange (BWE) plan.

b) Where the flow-through method of water ballast exchange is used, the design of water ballast exit arrangements are to be such that when the tank or hold is overflowing at the maximum pumping capacity available to the tank or hold, it is not subject to a pressure greater than that for which it has been designed.

c) Every ballast tank and hold intended for the carriage of water ballast is to be provided with isolating valves for filling and /or emptying purposes.

d) On ships classed for navigation in ice, ship side ballast discharge valves placed above the assigned lightest load line are to be arranged with adequate heating arrangements.

7.3.4 Sea chests and shipside openings intended for ballast water exchange

The relative positions of ballast water intake and discharge openings are to be such as to preclude as far as practicable the possibility of contamination of replacement ballast water by water which is being pumped out.

7.3.5 Pumps

a) The ballast system is to be served by at least two pumps.

b) The complete ballast water exchange of cargo holds, where used for the carriage of water ballast, shall be possible by one pump within not more than twenty four hours.

7.3.6 System arrangement

a) The design of ballast water systems is to allow the ballast water exchange operations with the minimum number of operational procedures.

b) The internal arrangements of ballast tanks, as well as ballast water piping inlet and outlet arrangements, are to allow, as far as practical, the complete ballast water exchange and the clearing of any sediments.

c) The design of sea suction line strainers is to be such as to permit cleaning of strainers without interrupting ballast water exchange procedures.

7.3.7 Control features

a) Remote control, local control, emergency control

- Remote control - ballast pumps, and all valves which may be operated during ballast water exchange are to be provided with a means of remote control from a central ballast control station.
- Local control - a means of local control is to be provided at each ballast pump operated during ballast water exchange.
- Emergency control - a readily accessible manual means for control of any valve required for ballast water exchange is to be also provided to enable the emergency operation in the event of main control system failure (see also 7.2.4, item b)).

b) The central ballast control station is to include the following:

- a valve position indicating system,
- a tank level indicating system,
- a draft indicating system,
- a means of communication between the central ballast control station and those spaces containing the means of local control for the ballast pumps and the manually operated independent means of control for the valves.

c) The ballast pump and ballast valve control systems are to be so arranged that the failure of any component within the control system is not to cause the loss of operation to the pumps or valves of other systems.

7.3.8 Tanks

a) For ships with a ICE class notation and, generally, where a risk of water ballast freezing exists, water ballast tanks are to be provided with means to prevent the water from freezing. See Part 5, Chapter 18.

b) The design of ballast tanks is to effort ready sampling of ballast water and sediments, as far as practical. Providing safe access to the tanks by the fitting of tank hatches as an alternative to manholes is recommended. The area immediately below any tank opening is to be free as in order to enable the use of sampling equipment or free access.

7.3.9 Special provisions depending on the method of ballast water exchange

a) Flow-through method

- The capability of the ballast water system to provide ballast water exchange by the flow-through method without the risk of the tank being subject to a pressure greater than that for which it has been designed is to be demonstrated by water flow calculations and by testing on board. Subject to consideration in each particular case, the calculation may be omitted where justified that total cross-sectional area of all vent pipes fitted to the tank is not less than twice the sectional area of the related filling pipes.
- The flow-through method with water flowing over the deck is not permitted. The use of collecting pipes, internal overflow pipes or interconnecting pipe/trunk arrangements between tanks may be accepted to avoid water flowing over the deck.

b) Dilution method

- Where the dilution method is accepted, arrangements are to be made to automatically maintain the ballast water level in the tanks at a constant level. These arrangements are to include the provision of a manual emergency stop for any operating ballast pump, in case of valve malfunction or incorrect control actions.
- High and low water level alarms are to be provided where maintaining a constant level in a tank is essential to the safety of the ship during ballast water exchange.

8 Scuppers and sanitary discharges

8.1 Application

8.1.1

a) This Article applies to:

- scuppers and sanitary discharge systems, and
- discharges from sewage tanks.

b) Discharges in connection with machinery operation are dealt with in [2.8].

Note 1: Arrangements not in compliance with the provisions of this Article may be considered for the following ships:

- ships of less than 24 m in length
- cargo ships of less than 500 tons gross tonnage
- ships to be assigned restricted navigation notations
- non-propelled units.

8.2 Principle

8.2.1

a) Scuppers, sufficient in number and suitable in size, are to be provided to permit the drainage of water likely to accumulate in the spaces which are not located in the ship's bottom.

b) The number of scuppers and sanitary discharge openings in the shell plating is to be reduced to a minimum either by making each discharge serve as many as possible of the sanitary and other pipes, or in any other satisfactory manner.

c) Except otherwise specified, the design of scuppers and sanitary discharges shall generally comply with recognized national or international standard acceptable to the Society (reference is made to ISO 15749-1 to -5, as applicable).

8.3 Drainage from spaces below the freeboard deck or within enclosed superstructures and deckhouses on the freeboard deck

8.3.1 Normal arrangement

Scuppers and sanitary discharges from spaces below the freeboard deck or from within superstructures and deckhouses on the freeboard deck fitted with doors complying with the provisions of requirements concerning side doors and stern doors are to be led to:

- the bilge in the case of scuppers, or
- suitable sanitary tanks in the case of sanitary discharges.

8.3.2 Alternative arrangement

The scuppers and sanitary discharges may be led overboard provided that:

- the spaces drained are located above the load waterline formed by a 5° heel, to port or starboard, at a draft corresponding to the assigned summer freeboard, and
- the pipes are fitted with efficient means of preventing water from passing inboard in accordance with:
  - 8.7 where the spaces are located below the margin line,
  - 8.8 where the spaces are located above the margin line.

Note 1: The margin line is defined as a line drawn at least 76 mm below the upper surface of:

- the bulkhead deck at side, for passenger ships,
- the freeboard deck at side, for cargo ships.

8.4 Drainage of superstructures or deckhouses not fitted with efficient weathertight doors

8.4.1 Scuppers leading from superstructures or deckhouses not fitted with doors complying with the requirements concerning side doors and stern doors are to be led overboard.

8.5 Drainage of enclosed cargo spaces situated on the bulkhead deck or on the freeboard deck

8.5.1 General

Means of drainage are to be provided for enclosed cargo spaces situated on the bulkhead deck of a passenger ship and on the freeboard deck of a cargo ship. The Society may permit the means of drainage to be dispensed with in any particular compartment if it is satisfied that, by reason of size or internal subdivision of such space, the safety of the ship is not impaired.

8.5.2 Cases of spaces located above the waterline resulting from a 5° heel

a) Scuppers led through the shell from enclosed superstructures used for the carriage of cargo are permitted, provided the spaces drained are located above the waterline resulting from a 5° heel to port or starboard at a draught corresponding to the assigned summer freeboard.

Such scuppers are to be fitted in accordance with the requirements stated in 8.7 or 8.8.

b) In other cases, the drainage is to be led inboard in accordance with the provisions of 8.5.3.

8.5.3 Cases where the bulkhead or freeboard deck edge is immersed when the ship heels 5° or less

Where the freeboard is such that the edge of the bulkhead deck or the edge of the freeboard deck, respectively, is immersed when the ship heels 5° or less, the drainage of the enclosed cargo spaces on the bulkhead deck or on the freeboard deck, respectively, is to be led to a suitable space, or spaces, of appropriate capacity, having a high water level alarm and provided with suitable arrangements for discharge overboard.

In addition, it is to be ensured that:

- the number, size and arrangement of the scuppers are such as to prevent unreasonable accumulation of free water
- the pumping arrangements take account of the requirements for any fixed pressure water-spraying fire-extinguishing system
- water contaminated with petrol or other dangerous substances is not drained to machinery spaces or other spaces where sources of ignition may be present, and
- where the enclosed cargo space is protected by a carbon dioxide fire-extinguishing system, the deck scuppers are fitted with means to prevent the escape of the smothering gas.

8.6 Drainage of cargo spaces, other than ro-ro spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion

8.6.1 Prevention of build-up of free surfaces

In cargo spaces, other than ro-ro spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion and fitted with a fixed pressure water-spraying fire-extinguishing system, the drainage arrangement is to be such as to prevent the build-up of free surfaces. If this is not possible, the adverse effect upon stability of the added weight and free surface of water are to be taken into account to the extent deemed necessary by the Society in its approval of the stability information. Refer to Part 3, Ch 3.

8.6.2 Scupper draining

Scuppers from cargo spaces, other than ro-ro spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion are not to be led to machinery spaces or other places where sources of ignition may be present.

8.7 Arrangement of discharges from spaces below the margin line

8.7.1 Normal arrangement

Each separate discharge led though the shell plating from spaces below the margin line is to be provided with one automatic non-return valve fitted with positive means of closing it from above the bulkhead or freeboard deck.

8.7.2 Alternative arrangement when the inboard end of the discharge pipe is above the summer waterline by more than 0.01 L

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0.01 L, the discharge may have two automatic non-return valves without positive means of closing, provided that the inboard valve:

- is above the deepest subdivision load line, and
- is always accessible for examination under service conditions.

8.8 Arrangement of discharges from spaces above the margin line

8.8.1 General

a) The provisions of this sub-article are applicable only to those discharges which remain open during the normal operation of a ship. For discharges which must necessarily be closed at sea, such as gravity drains from topside ballast tanks, a single screw-down valve operated from the deck may be accepted.

b) The position of the inboard end of discharges is related to the timber summer load waterline when a timber freeboard is assigned.

8.8.2 Normal arrangement

Normally, each separate discharge led though the shell plating from spaces above the margin line is to be provided with:

- one automatic non-return valve fitted with positive means of closing it from a position above the bulkhead or freeboard deck, or
- one automatic non-return valve and one sluice valve controlled from above the bulkhead or freeboard deck.

8.8.3 Alternative arrangement when the inboard end of the discharge pipe is above the summer waterline by more than 0.01 L

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0.01 L, the discharge may have two automatic non-return valves without positive means of closing, provided that:

- the inboard valve is above the level of the tropical load waterline so as to always be accessible for examination under service conditions, or
- where this is not practicable, a locally controlled sluice valve is interposed between the two automatic nonreturn valves.

8.8.4 Alternative arrangement when the inboard end of the discharge pipe is above the summer waterline by more than 0.02 L

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0.02 L, a single automatic non-return valve without positive means of closing may be accepted subject to the approval of the Society.

Note 1: This requirement does not apply to ships for which the notation chemical tanker or liquefied gas carrier is requested.

8.8.5 Arrangement of discharges through manned machinery spaces

Where sanitary discharges and scuppers lead overboard through the shell in way of machinery spaces, the fitting at the shell of a locally operated positive closing valve together with a non-return valve inboard may be accepted.

The operating position of the valve will be given special consideration by the Society.

8.8.6 Arrangement of discharges through the shell more than 450 mm below the freeboard deck or less than 600 mm above the summer load waterline

Scupper and discharge pipes originating at any level and penetrating the shell either more than 450 millimetres below the freeboard deck or less than 600 millimetres above the summer load waterline are to be provided with a non-return valve at the shell. Unless required by 8.8.2 to 8.8.4, this valve may be omitted if the piping is of substantial thickness, as per Table 8.2.

8.8.7 Arrangement of discharges through the shell less than 450 mm below the freeboard deck and more than 600 mm above the summer load waterline

Scupper and discharge pipes penetrating the shell less than 450 mm below the freeboard deck and more than 600 mm above the summer load waterline are not required to be provided with a non-return valve at the shell.

8.9 Summary table of overboard discharge arrangements

8.9.1 The various arrangements acceptable for scuppers and sanitary overboard discharges are summarized in Figure 8.1.

8.10 Valves and pipes

8.10.1 Materials

a) All shell fittings and valves are to be of steel, bronze or other ductile material. Valves of ordinary cast iron or similar material are not acceptable. All scupper and discharge pipes are to be of steel or other ductile material. Refer to 2.1.

b) Plastic is not to be used for the portion of discharge line from the shell to the first valve.

8.10.2 Thickness of pipes

a) The thickness of scupper and discharge pipes led to the bilge or to draining tanks is not to be less than that required in 2.2.

b) The thickness of scupper and discharge pipes led to the shell is not to be less than the minimum thickness given in Table 8.1 and Table 8.2.

8.10.3 Operation of the valves

a) Where valves are required to have positive means of closing, such means is to be readily accessible and provided with an indicator showing whether the valve is open or closed.

b) Where plastic pipes are used for sanitary discharges and scuppers, the valve at the shell is to be operated from outside the space in which the valve is located.

Where such plastic pipes are located below the summer waterline (timber summer load waterline), the valve is to be operated from a position above the freeboard deck. Refer also to App 1.

Figure 8.1: Overboard discharge arrangement

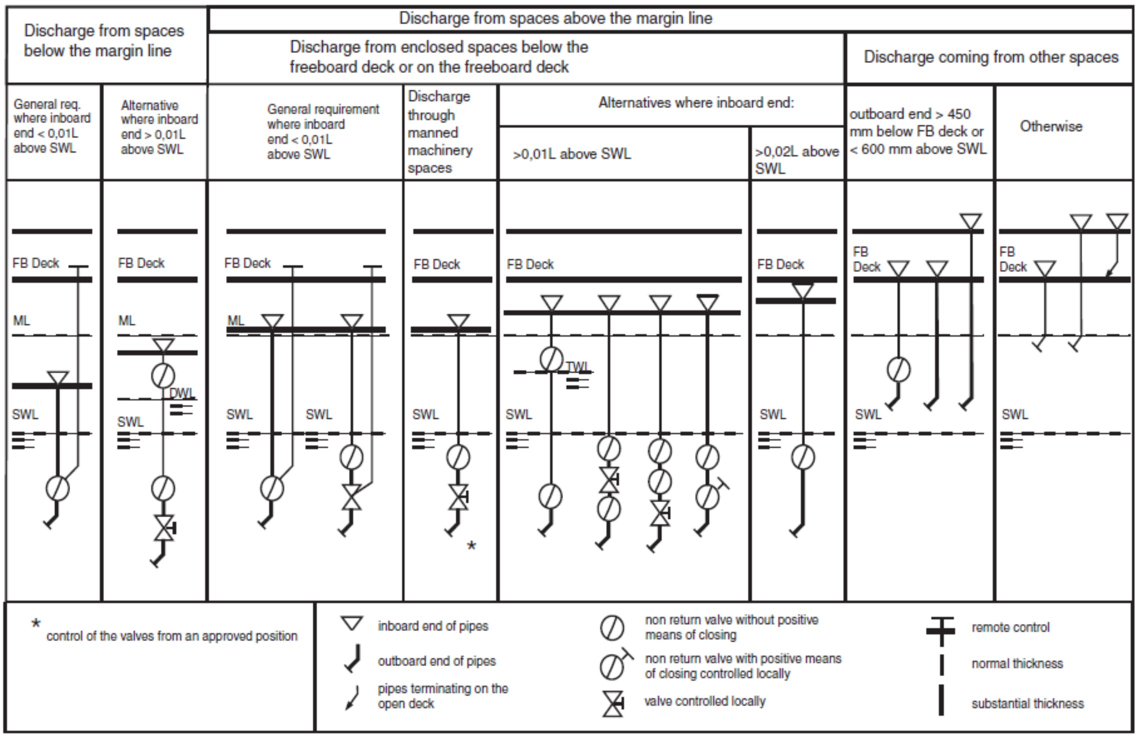


Table 8.1: Thickness of scupper and discharge pipes led to the shell, according to their location

<table>
<tr><th>Applicable Requirement / Pipe location</th><th>8.7.1</th><th>8.7.2</th><th>8.8.2</th><th>8.8.3</th><th>8.8.4</th><th>8.8.5</th><th>8.8.6 with valve</th><th>8.8.6 without valve</th><th>8.8.7</th></tr>
<tr><td>Between the shell and the first valve</td><td colspan="7">Thickness according to Table 8.2, column 1, or 0.7 times that of the shell side plating, whichever is the greater (1)</td><td>NA</td><td>NA</td></tr>
<tr><td>Between the first valve and the inboard end</td><td colspan="7">Thickness according to Table 8.2, column 2</td><td>NA</td><td>NA</td></tr>
<tr><td>Below the freeboard deck</td><td colspan="7">NA</td><td>Thickness according to Table 8.2, column 1</td><td>Thickness according to Table 8.2, column 2</td></tr>
<tr><td>Above the freeboard deck</td><td colspan="7">NA</td><td>Thickness according to Table 8.2, column 2</td><td>Thickness according to Table 8.2, column 2</td></tr>
</table>

(1) However, this thickness is not required to exceed that of the plating.

Note 1: NA = not applicable.

8.11 Arrangement of scuppers and sanitary discharge piping

8.11.1 Overboard discharges and valve connections

a) Overboard discharges are to have pipe spigots extending through the shell plate and welded to it, and are to be provided at the internal end with a flange for connection to the valve or pipe flange.

b) Valves may also be connected to the hull plating in accordance with the provisions of 2.8.3, item c).

8.11.2 Passage through cargo spaces

Where scupper and sanitary discharge pipes are led through cargo spaces, the pipes and the valves with their controls are to be adequately protected by strong casings or guards.

8.11.3 Passage through tanks

a) As a rule, scupper and sanitary discharge pipes are not to pass through fuel oil tanks.

b) Where scupper and discharge pipes pass unavoidably through fuel oil tanks and are led through the shell within the tanks, the thickness of the piping is not to be less than that given in Table 8.2, column 1 (substantial thickness). It need not, however, exceed the thickness of the adjacent Rule shell plating.

c) Scupper and sanitary discharge pipes are normally not to pass through fresh and drinking water tanks.

d) For passage through cargo oil tanks, see Part 5, Ch 5.

Table 8.2: Minimum thickness of scupper and discharge pipes led to the shell

External diameter of the pipe d (mm)	Column 1 Substantial thickness (mm) (1)	Column 2 normal thickness (mm)
d≤80.0	7,00	4,50
155	9,25	4,50
180	10,00	5,00
220	12,50	5,80
230≤d	12,50	6,00

(1) For pipes connected to the shell below the freeboard deck, refer to minimum extra-reinforced wall thicknesses given in Table 2.2.

Note 1: Intermediate sizes may be determined by interpolation.

8.11.4 Passage through watertight bulkheads or decks

a) The intactness of machinery space bulkheads and of tunnel plating required to be of watertight construction is not to be impaired by the fitting of scuppers discharging to machinery spaces or tunnels from adjacent compartments which are situated below the freeboard deck.

b) Such scuppers may, however, be led into a strongly constructed scupper drain tank situated in the machinery space or tunnel, but close to the above-mentioned adjacent compartments and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

8.11.5 Discharge in refrigerated spaces

No scupper pipe from non-refrigerated spaces is to discharge in refrigerated spaces.

8.11.6 Discharge from galleys and their stores

Discharges from galleys and their stores are to be kept separate from other discharges and be drained overboard or in separate drainage tanks; alternatively, discharges are to be provided with adequate devices against odours and overflow.

8.11.7 Discharge from aft spaces

Where spaces located aft of the aft peak bulkhead not intended to be used as tanks are drained by means of scuppers discharging to the shaft tunnel, the provisions of 6.6.4 item c) are to be complied with.

8.11.8 Scupper tank

a) The scupper tank air pipe is to be led to above the freeboard deck.

b) Provision is to be made to ascertain the level of water in the scupper tank.

8.11.9 Drains from the funnels

Drain line from the funnel or stack top should not terminate on an exposed deck owing to the soot that may be contained in the wastewater. Except otherwise specified, this line may be connected to other lines draining exposed decks and leading directly overboard, taking into consideration the quantity of wastewater occurring.

8.11.10 Sewage and grey water discharges

The requirements specified below are general and should apply to any ship fitted with sewage and grey water piping systems. They are not sufficient for the compliance with MARPOL Annex IV and for additional class notation CLEANSHIP. Furthermore, the National Authority of the country in which the ship is to be registered may also have additional requirements.

a) Except otherwise specified, the sewage (or black water) means:

- drainage and other wastes from any form of toilets, urinals, and WC scuppers
- drainage from medical premises (dispensary, sick bay, etc.) via wash basins, wash tubs and scuppers located in such premises
- drainage from spaces containing living animals; or
- other waste waters when mixed with the drainages defined above.

b) Grey water means other sanitary discharges which are not sewage.

c) In general, sewage systems should be of a design which will avoid the possible generation of toxic and flammable gases (such as hydrogen sulphide, methane, ammonia) during the sewage collection and treatment.

Additional means of protection is to be suitable ventilation of the pipe work and tanks.

d) Drain lines from the hospital area should be, as far as practicable, separated from other discharges and fitted to the drain collector at the lowest level.

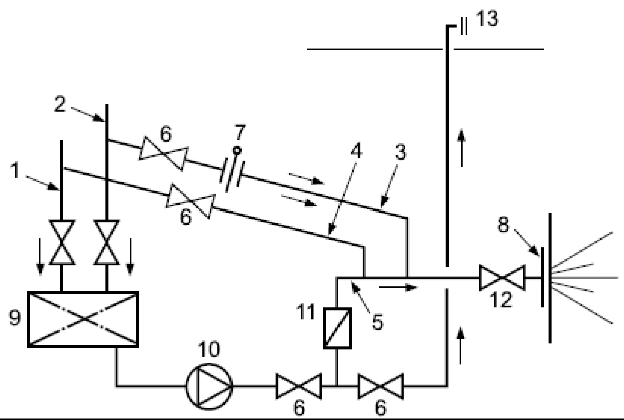
e) Sewage and grey water may be collected into storage tanks together or separately, either for holding prior to transfer to a treatment unit, or for later discharge. Any tank used for holding sewage shall comply with the following:

- suitable air pipes shall be fitted, leading to the open deck
- design and configuration of those tanks should be such as to facilitate the effective drainage and flushing of the tanks
- suitable means for flushing of the tanks shall be provided
- such tanks are to be efficiently protected against corrosion
- tanks shall have a means to indicate visually the amount of its content and, for additional class notation AUT, high level alarm is to be fitted
- suitable means for emptying sewage tanks through the standard discharge connection to reception facilities shall be provided. Ballast and bilge pumps are not be used for that purpose.

f) Air pipes from the sewage and grey water systems are to be independent of all other air pipes and to be led to the outside of the ship, away from any air intake. Such pipes should not terminate in areas to which personnel have frequent access and should be clear of any sources of ignition.

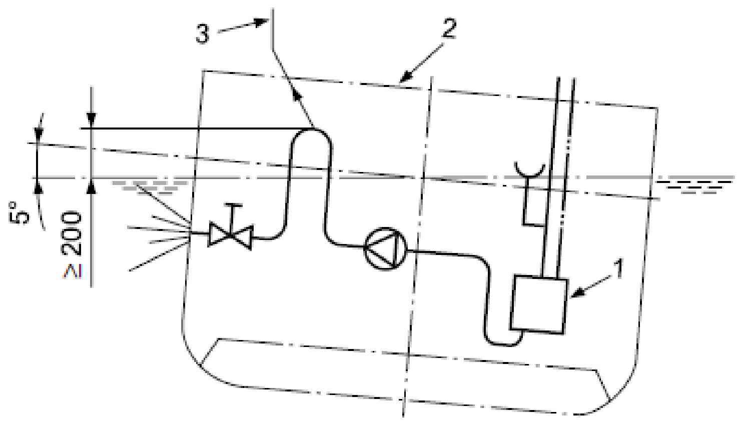
g) The overboard discharges shall be located as far from seawater inlets as possible, seen in the direction of travel. In general, the sewage outlets should be located below the summer loadline.

Figure 8.2: Sewage and grey water overboard discharge typical arrangement



1 grey water drain line	8 overboard discharge
2 sewage water drain line	9 collector tank or treatment unit
3 bypass line for sewage	10 pump
4 bypass line for grey water	11 non-return valve
5 sewage disposal line	12 screw-down overboard valve
6 shutoff gate valve	13 standard discharge connection.
7 spectacle flange, optional	

Figure 8.3 : Typical overboard discharge arrangement without non-return valve



1 collector tank or treatment unit

2 freeboard deck

3 vent (leading on top of funnel.

h) The sewage and grey water discharge lines are to be fitted at the ships' side with screw-down valve and nonreturn valve. Possible characteristically arrangement is shown on Figure 8.2.

The non-return valve may be omitted where a pipe loop is fitting on discharge line, provided that the lowest part of the loop is at least 200 mm above the waterline with the ship on summer loadline draft and when the ship has a 5° list (see Figure 8.3).

9 Air, sounding and overflow pipes

9.1 Air pipes

9.1.1 Principle

Air pipes are to be fitted to all tanks, double bottoms, cofferdams, tunnels and other compartments which are not fitted with alternative ventilation arrangements, in order to allow the passage of air or liquid so as to prevent excessive pressure or vacuum in the tanks or compartments, in particular in those which are fitted with piping installations. Their open ends are to be so arranged as to prevent the free entry of sea water in the compartments.

9.1.2 Number and position of air pipes

a) Air pipes are to be so arranged and the upper part of compartments so designed that air or gas likely to accumulate at any point in the compartments can freely evacuate.

b) Air pipes are to be fitted opposite the filling pipes and/or at the highest parts of the compartments, the ship being assumed to be on an even keel.

c) In general, two air pipes are to be fitted for each compartment, except in small compartments, where only one air pipe may be accepted. When the top of the compartment is of irregular form, the position of air pipes will be given special consideration by the Society.

Note 1: Two air vents are normally required for long tanks e.g. a ballast tank in a double hull ship. In machinery spaces, two air vents are not normally required.

d) Where only one air pipe is provided, it is not to be used as a filling pipe.

9.1.3 Location of open ends of air pipes

a) Air pipes of double bottom compartments, tunnels, deep tanks and other compartments which can come into contact with the sea or be flooded in the event of hull damage are to be led to above the bulkhead deck or the freeboard deck.

Note 1: In ships 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 above the bulkhead deck or the freeboard deck.

c) Air pipes other than those of flammable oil tanks may be led to enclosed cargo spaces situated above the freeboard deck, provided that:

- overflow pipes are fitted in accordance with 9.3.4, where the tanks may be filled by pumping

- enclosed cargo spaces are fitted with scuppers discharging overboard and being capable of draining all the water which may enter through the air pipes without giving rise to any water accumulation
- suitable drainage arrangement is to be fitted below the air pipe outlet, leading to the nearest scupper
- such arrangement is not to impair integrity of fire divisions or watertight decks and bulkheads subject to the damage stability requirements.

d) Unless otherwise specified, in passenger ships the open end of air pipes terminating within a superstructure shall be at least 1 m above the waterline when the ship heels to an angle of 15°, or the maximum angle of heel during intermediate stages of flooding, as determined by direct calculation, whichever is the greater. Alternatively, air pipes from tanks other than oil tanks may discharge through the side of the superstructure.

e) The air pipe of the scupper tank is to be led to above freeboard deck.

f) The location of air pipes for flammable oil tanks is also to comply with 9.1.7.

9.1.4 Height of air pipes

a) The height of air pipes extending above the freeboard deck or superstructure deck from the deck to the point where water may have access below is to be at least:

- 760 mm on the freeboard deck, and
- 450 mm on the superstructure deck.

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 ship, a lower height may be approved, provided the Society is satisfied that this is justified by the closing arrangements and other circumstances. Satisfactory means which are permanently attached are to be provided for closing the openings of the air pipes.

c) The height of air pipes may be required to be increased on ships subject to damage stability requirements since the air pipe outlets should be above final water line at any damaged condition assumed by the Damage stability examination as defined in Part 3, Ch 3.

d) The height of air pipes discharging through the side of the superstructure is to be at least 2.3 m above the summer load waterline.

9.1.5 Fitting of closing appliances

a) Satisfactory appliances which are permanently attached are to be provided for closing the openings of air pipes in order to prevent the free entry of water into the spaces concerned, except for pipes of tanks fitted with cross-flooding connections.

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

- where air pipes to ballast and other tanks extend above the freeboard or superstructure decks

- where, with the ship at its summer load waterline, the openings are immersed at an angle of heel of 40° or, at the angle of down-flooding if the latter is less than 40°
- where, as per 9.1.3 item c), air pipes terminate in enclosed spaces
- where, as per 9.1.4 item b), air pipes have a height lower than that required in 9.1.4 item a)
- and for ships assigned timber freeboard.

c) Automatic closing appliances are to be of a type approved by the Society. Requirements for type tests are given in 20.2.2.

d) For ships subject to specific buoyancy or stability requirements, the fitting of closing appliances to air pipes will be given special consideration.

e) Pressure/vacuum valves installed on cargo tanks, as per Part 5, Chapters 5 and 6, can be accepted as closing appliances.

9.1.6 Design of closing appliances

a) When closing appliances are requested to be of an automatic type, they are to comply with the following:

- They are to prevent free entry of water into the tanks.
- They are to allow the passage of air or liquid to prevent excessive pressure or vacuum coming on the tank.
- They are to be so designed that they withstand both ambient and working conditions up to an inclination of -40° to +40° without failure or damage.
- They are to be so designed as to allow inspection of the closure and the inside of the casing as well as changing of the seals.
- Where they are of the float type, suitable guides are to be provided to ensure unobstructed operation under all working conditions of heel and trim.
- Efficient seating arrangements are to be provided for the closures.
- They are to be self-draining.
- The clear area through an air pipe closing appliance is to be at least equal to the area of the inlet.
- The maximum allowable tolerances for wall thickness of floats is not to exceed ±10% of the nominal thickness.
- Their casings are to be of approved metallic materials adequately protected against corrosion.
- Closures and seats made of non-metallic materials are to be compatible with the media to be carried in the tank and with sea water at ambient temperatures between -25°C and +85°C.

b) Where closing appliances are not of an automatic type, provision is to be made for relieving vacuum when the tanks are being pumped out. For this purpose, a hole of approximately 10 mm in diameter may be provided in the bend of the air pipe or at any other suitable position in the closing appliance.

c) Wooden plugs and trailing canvas are not permitted in position 1 or position 2, as defined in Part 3, Ch.1, Sec.1.

9.1.7 Special arrangements for air pipes of flammable oil tanks

a) Air pipes from fuel oil and thermal oil tanks are to discharge to a safe position on the open deck where no danger will be incurred from issuing oil or gases.

Where fitted, wire gauze diaphragms are to be 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, which are neither heated nor subject to flooding in the event of hull damage, may be led to machinery spaces, provided that in the case of overflowing the oil cannot come into contact with electrical equipment, hot surfaces or other sources of ignition.

c) The location and arrangement of vent pipes for fuel oil service, settling and lubrication oil tanks are to be such that in the event of a broken vent pipe there is no risk of ingress of seawater or rainwater.

d) Air pipes of fuel oil service, settling and lubrication oil tanks likely to be damaged by impact forces are to be adequately reinforced.

e) Where seawater or rainwater may enter fuel oil service, settling and lubrication oil tanks through broken air pipes, arrangements such as water traps with:

- automatic draining, or
- alarm for water accumulation are to be provided.

9.1.8 Construction of air pipes

a) Where air pipes to ballast and other tanks extend above the freeboard deck or superstructure deck, the exposed parts of the pipes are to be of substantial construction, with a minimum wall thickness of at least:

- 6.0 mm for pipes of 80 mm or smaller external diameter
- 8.5 mm for pipes of 165 mm or greater external diameter, Intermediate minimum thicknesses may be determined by linear interpolation.

b) Air pipes with height exceeding 900 mm are to be additionally supported.

c) In each compartment likely to be pumped up, and where no overflow pipe is provided, the total cross-sectional area of air pipes is not to be less than 1.25 times the cross-sectional area of the corresponding filling pipes.

d) The internal diameter of air pipes is not to be less than 50 mm, except for tanks of less than 2 m^3.

e) Air pipes from several tanks or spaces may be led into a common main line, provided that:

- the tanks or spaces are not intended for liquids which are not compatible and that the arrangement could not effect unacceptable condition for the ship
- the cross-sectional area of the air pipes main is generally not less than the aggregate cross-sectional area of the two largest pipes discharging into the main. However, a reduced value may be considered for acceptance in each particular case on the basis of back pressure calculation submitted for all normal working conditions
- as far as practical, each separate air pipe is fitted to the common air pipe from the top side
- where no overflow pipes are provided, the cross sectional area of a common air pipe from several tanks is not less than 1.25 times the area of the common filling pipeline for these tanks
- where the tanks or spaces are situated at the shell side, the connections to the air pipes main are to be above the freeboard deck. Where it is not practical, different position proposed as far as possible above the deepest load waterline may be considered for acceptance. For vessels subject to damage stability requirements these connections should be above final water line at any damaged condition assumed by the Damage stability examination as defined in Part 3, Ch 3.

f) Vents acting also as overflows may be accepted provided all the requirements applicable to both vents and overflows are complied with.

g) Where tanks are fitted with cross flooding connections, the air pipes are to be of adequate area for these connections.

9.1.9 Strength requirements to resist green sea forces for the air pipes, ventilator pipes and their closing devices located within the forward quarter length

a) In addition to all other requirements specified before, the following shall apply on the exposed deck over the forward 0.25 L, applicable to:

- All ship types of sea going service of length 80 m or more, where the height of the exposed deck in way of the item is less than 0.1 L or 22 m above the summer load waterline, whichever is the lesser.
- For application to existing ships (that are contracted for construction prior to 1 January 2004), see Part 1, Ch 2, Sections 8 and 9.

The rule length “L” is the distance, in m, taken as defined in Part 3.

The requirements do not apply to the cargo tank venting systems and the inert gas systems of tankers.

b) Generally, the bending moments and stresses in air and ventilator pipes are to be calculated at following critical positions:

- at penetration pieces
- at weld or flange connections
- at toes of supporting brackets.

Bending stresses in the net section are not to exceed 0.8 of the specified minimum yield stress or 0.2% proof stress of the steel at room temperature. Irrespective of corrosion protection, a corrosion addition to the net section of 2.0 mm is then to be applied.

Relevant drawing and calculation shall be submitted.

c) For standard air pipes of 760 mm height closed by heads of not more than the tabulated projected area, pipe thickness and bracket heights are specified in Tab 9.1. Where brackets are required, three or more radial brackets are to be fitted. Brackets are to be of gross thickness 8 mm or more, of minimum length 100 mm, and height according to Table 9.2 but need not extend over the joint flange for the head. Bracket toes at the deck are to be suitably supported.

d) For other configurations, loads according to item i) are to be applied, and means of support determined in order to comply with the requirements of item b). Brackets, where fitted, are to be of suitable thickness and length according to their height. Pipe thickness is not to be taken less than as indicated in 9.1.8.

e) For standard ventilators of 900 mm height closed by heads of not more than the tabulated projected area, pipe thickness and bracket heights are specified in Tab 9.2. Brackets, where required are to be as specified in item c).

f) For ventilators of height greater than 900 mm, brackets or alternative means of support shall be fitted according to the arrangement acceptable to the Society. Pipe thickness is not to be taken less than as indicated in 9.1.8.

g) All component parts and connections of the air pipe or ventilator are to be capable of withstanding the loads defined in item i).

h) Rotating type mushroom ventilator heads are not suitable for application in the areas where these requirements are applied.

i) Applied loading may be calculated:

- The pressures p, in kN/m^2, acting on air pipes, ventilator pipes and their closing devices may be calculated from:

$$p = 0.5\,\rho V^2 C_d C_s C_p$$

where:

ρ: Density of sea water, equal to 1.025 t/m^3

V : Velocity of water over the fore deck, equal to 13.5 m/sec

C_d : Shape coefficient, equal to:

- 0.5 for pipes
- 1.3 for air pipe or ventilator heads in general
- 0.8 for an air pipe or ventilator head of cylindrical form with its axis in the vertical direction

C_s : Slamming coefficient, equal to 3.2

C_p : Protection coefficient, equal to:

- 0.7 for pipes and ventilator heads located immediately behind a breakwater or a forecastle
- 1.0 elsewhere and immediately behind a bulwark.

• Forces acting in the horizontal direction on the pipe and its closing device may be calculated from formula above, using the largest projected area of each component.

Table 9.1: 760 mm air pipe thickness and bracket standards

Nominal pipe diameter (mm)	Minimum fitted gross thickness(mm)	Maximum projected area of head (cm^2)	Height of brackets (1) (mm)
40A (3)	6.0	-	520
50A (3)	6.0	-	520
65A	6.0	-	480
80A	6.3	-	460
100A	7.0	-	380
125A	7.8	-	300
150A	8.5	-	300
175A	8.5	-	300
200A	8.5 (2)	1900	300 (2)
250A	8.5 (2)	2500	300 (2)
300A	8.5 (2)	3200	300 (2)
350A	8.5 (2)	3800	300 (2)
400A	8.5 (2)	4500	300 (2)

(1) Brackets (see 9.1.9 items b) to h)) need not extend over the joint flange for the head.

(2) Brackets are required where the as fitted (gross) thickness is less than 10.5 mm, or where the tabulated projected head area is exceeded.

(3) Not permitted for new ships - see Table 2.2.

Note 1: For other air pipe heights, the relevant requirements of 9.1.9 are to be applied.

Table 9.2: 900 mm ventilator pipe thickness and bracket standards

Nominal pipe diameter (mm)	Minimum fitted gross thickness, (mm)	Maximum projected area of head (cm^2)	Height of brackets(mm)
80A	6,3	–	460
100A	7,0	–	380
150A	8,5	–	300
200A	8,5	550	–
250A	8,5	880	–
300A	8,5	1200	–
350A	8,5	2000	–
400A	8,5	2700	–
450A	8,5	3300	–
500A	8,5	4000	–

Note 1: For other ventilator heights, the relevant requirements of 9.1.9, items b) to h), are to be applied.

9.2 Sounding pipes

9.2.1 Principle

a) Sounding devices are to be fitted to tanks intended to contain liquids as well as to all compartments which are not readily accessible at all times.

b) For compartments normally intended to contain liquids, the following systems may be accepted in lieu of sounding pipes:

- a level gauge of an approved type efficiently protected against shocks, or
- a remote level gauging system of an approved type, provided an emergency means of sounding is available in the event of failure affecting such system.

9.2.2 Position of sounding pipes

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

9.2.3 Termination of sounding pipes

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

b) In machinery spaces and tunnels, where the provisions of item 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 ships required to be fitted with a double bottom, such closing appliances are to be of the self-closing type.

9.2.4 Special arrangements for sounding pipes of flammable oil tanks

a) Where sounding pipes are used in flammable (except lubricating) oil systems, they are to terminate in the open air, where no risk of ignition of spillage from the sounding pipe might arise. In particular, they are not to terminate in passenger or crew spaces. As a general rule, they are not to terminate in machinery spaces.

However, where the Society considers that this requirement is impracticable, it may permit termination in machinery spaces on condition that the following provisions are satisfied:

1) in addition, an oil-level gauge is provided meeting the provisions of 2.9.2

2) the sounding pipes terminate in locations remote from ignition hazards unless precautions are taken, such as the fitting of effective screens, to prevent the fuel oil in the case of spillage through the terminations of the sounding pipes from coming into contact with a source of ignition

3) the terminations of sounding pipes are fitted with self-closing blanking devices and with a small diameter self-closing control cock located below the blanking device for the purpose of ascertaining before the blanking device is opened that fuel oil is not present. Provision is to be made so as to ensure that any spillage of fuel oil through the control cock involves no ignition hazard.

b) For lubricating oil and fuel oil leakage tanks less than 2 m^3, the oil-level gauge mentioned in a) 1) and the control cock mentioned in a) 3) need not be provided on condition that the sounding pipes are fitted with appropriate means of closure.

c) Short sounding pipes may be used for tanks other than double bottom tanks without the additional closed level gauge provided an overflow system is fitted.

9.2.5 Closing appliances

a) Self-closing appliances are to be fitted with cylindrical plugs having counterweights such as to ensure automatic closing.

b) Closing appliances not required to be of the self-closing type may consist of a metallic screw cap secured to the pipe by means of a chain or a shut-off valve.

9.2.6 Construction of sounding pipes

a) Sounding pipes are normally to be straight. If it is necessary to provide bends in such pipes, the curvature is to be as small as possible to permit the ready passage of the sounding apparatus.

b) In cargo ships, the sounding arrangement of compartments by means of bent pipes passing through other compartments will be given special consideration by the Society. Such an arrangement is normally accepted only if the compartments passed through are cofferdams or are intended to contain the same liquid as the compartments served by the sounding pipes.

c) Bent portions of sounding pipes are to have reinforced thickness and be suitably supported.

d) The internal diameter of sounding pipes is not to be less than 32 mm. Where sounding pipes pass through refrigerated spaces, or through the insulation of refrigerated spaces in which the temperature may be below 0°C, their internal diameter is to be at least 60 mm.

e) Doubling plates are to be placed under the lower ends of sounding pipes in order to prevent damage to the hull. When sounding pipes with closed lower ends are used, the closing plate is to have reinforced scantlings.

9.3 Overflow pipes

9.3.1 Principle

Overflow pipes are to be fitted to tanks:

- which can be filled by pumping and are designed for a hydrostatic pressure lower than that corresponding to the height of the air pipe, or
- where the cross-sectional area of air pipes is less than that prescribed in 9.1.8, item d).

9.3.2 Design of overflow systems

a) Overflow pipes are to be led:

- either outside, or

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

b) Where tanks containing the same or different liquids are connected to a common overflow system, the arrangement is to be such as to prevent any risk of:

- intercommunication between the various tanks due to movements of liquid when emptying or filling, or due to the inclination of the ship
- overfilling of any tank from another assumed flooded due to hull damage.
- For this purpose, overflow pipes are to be led to a high enough point above the deepest load waterline or, alternatively, non-return valves are to fitted where necessary.

c) Arrangements are to be made so that a compartment cannot be flooded from the sea through the overflow in the event of another compartment connected to the same overflow main being bilged. To this end, the openings of overflow pipes discharging overboard are as a rule to be placed above the deepest load waterline and are to be fitted where necessary with non-return valves on the plating, or, alternatively, overflow pipes from tanks are to be led to a point above the deepest load waterline.

d) Where deep tanks which can be used to contain liquid or dry cargo or fuel oil are connected to a common overflow system, arrangements are to be made so that liquid or vapours from other compartments cannot enter such tanks when carrying dry cargo.

e) Where tanks alternately containing fuel oil and ballast water are connected to a common overflow system, arrangements are to be made to prevent the ballast water overflowing into the tanks containing fuel oil and vice-versa.

f) Additional requirements for ships subject to damage stability checks are given in 5.5.3.

9.3.3 Overflow tanks

a) Overflow tanks are to have a capacity sufficient to receive the delivery of the pumps for at least 10 minutes.

b) Overflow tanks are to be fitted with an air pipe complying with 9.1 which may serve as an overflow pipe for the same tank. When the vent pipe reaches a height exceeding the design head of the overflow tank, suitable means are to be provided to limit the actual hydrostatic head on the tank.

Such means are to discharge to a position which is safe in the opinion of the Society.

c) An alarm device is to be provided to give warning when the oil reaches a predetermined level in the tank, or alternatively, a sight-flow glass is to be provided in the overflow pipe to indicate when any tank is overflowing.

Such sight-flow glasses are only to be placed on vertical pipes and in readily visible positions.

9.3.4 Specific arrangements for construction of overflow pipes

a) The internal diameter of overflow pipes is not to be less than 50 mm.

b) In each compartment which can be pumped up, the total cross-sectional area of overflow pipes is not to be less than 1.25 times the cross-sectional area of the corresponding filling pipes.

c) The cross-sectional area of the overflow main is not to be less than the aggregate cross-sectional area of the two largest pipes discharging into the main.

d) Where overflow sight glasses are provided, they shall be in a vertically dropping line on readily visible position, fitted with adequate protection from mechanical damage and well lit. The overflow sight glasses are not to be used in fuel oil systems. Use of the overflow sight glasses in lubricating oil systems may be accepted provided that:

- they are so designed that oil does not impinge on the glass
- the glass is to be of heat resisting quality.

In manned machinery spaces of ships other than passenger ships, if it is justified that other technical solution would not be practical, acceptance of the overflow sight glasses in fuel oil systems shall be subject to special consideration by the Society in each particular case, taking into consideration the installation conditions and categorization of the space.

9.4 Constructional requirements applying to sounding, air and overflow pipes

9.4.1 Materials

a) Sounding, air and overflow pipes are to be made of steel or any other material approved for the application considered.

b) Exposed parts of sounding, air and overflow pipes are to be made of approved metallic materials.

9.4.2 Minimum thickness of steel pipes

The minimum thickness of sounding, air and overflow steel pipes is given in Table 2.2. See also 9.1.9.

9.4.3 Passage of pipes through certain spaces

a) Air pipes and sounding pipes led through refrigerated cargo holds or spaces are to be suitably insulated.

b) 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 Table 2.2.

c) Sounding, air and overflow pipes passing through cargo holds are to be adequately protected.

9.4.4 Self-draining of pipes

Air pipes and overflow pipes are to be so arranged as to be self-draining when the ship is on an even keel.

9.4.5 Name plates

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

10 Cooling systems

10.1 Application

10.1.1 This article applies to all cooling systems using the following cooling media:

- sea water
- fresh water
- lubricating oil.

Air cooling systems will be given special consideration.

10.2 Principle

10.2.1 General

Sea water and fresh water cooling systems are to be so arranged as to maintain the temperature of the cooled media (lubricating oil, hydraulic oil, charge air, etc.) for propulsion machinery and essential equipment within the manufacturers' recommended limits during all operations, including starting and maneuvering, under the inclination angles and the ambient conditions specified in Ch 1, Sec 1.

10.2.2 Availability of the cooling system

The cooling system is to be so designed that, in the event of one essential component being inoperative, the cooling of propulsion machinery is maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the ship is not impaired.

10.3 Design of sea water cooling systems

10.3.1 General

a) Sea water cooling of the propulsion engines, auxiliary engines and other essential equipment is to be capable of being supplied by two different means.

b) Where required, standby pumps are not to be connected to the sea inlet serving the other sea water pumps, unless permitted under 10.7.1, item b).

10.3.2 Centralized cooling systems

a) In the case of centralized 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 and heat exchangers 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
- two heat exchangers, each having at least 50% of the total capacity necessary to provide cooling water to all the equipment served.

b) Where the cooling system is served by a group of identical pumps, the capacity of the standby pump needs only to be equivalent to that of each of these pumps.

c) Ballast pumps or other suitable sea water pumps of appropriate capacity may be used as standby pumps, provided arrangements are made against overpressure in the cooling system.

d) In ships having one or more propulsion engines, each with an output not exceeding 375 kW, the independent standby pump may be replaced by a complete spare pump of appropriate capacity ready to be connected to the cooling circuit.

e) In cases of centralized cooling systems serving only a group of auxiliary engines, the second means of cooling may consist of a connection to a cooling water pump serving the propulsion plant, provided such pump is of sufficient capacity to provide cooling water to both propulsion plant and auxiliary engines.

10.3.3 Individual cooling of propulsion engines

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

- one main cooling water pump, which can be driven by the engine
- one independently driven standby pump
- two heat exchangers having an aggregate capacity of at least 100% of that required by the engine.
- Where the output of the engine does not exceed 375 kW, the following arrangements may be accepted:
- one main cooling water pump, which can be driven by the engine
- one spare pump of appropriate capacity ready to be connected to the cooling circuit
- one heat exchanger of appropriate capacity.

b) Where, in ships having more than one engine per propeller or having several propellers, each engine is served by its own cooling circuit, the second means requested in 10.3.1 is to be provided, consisting of:

- a connection to an independently driven pump, such as a ballast pump or any other suitable sea water pump of sufficient capacity provided arrangements against overpressure in the cooling system are made. (See 10.7.4, item b)), or
- a complete spare pump identical to those serving the engines and ready to be connected to the cooling circuit.

This second means may be omitted, however, when safety justifications are provided as regards the propulsion and maneuvering capabilities of the ship with one cooling circuit disabled.

10.3.4 Individual cooling of auxiliary engines

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

10.3.5 Cooling of steam plants

a) Steam plants are to be fitted with:

- a main circulating pump

- a standby pump capable of ensuring the circulation in the main condenser in the event of failure of the main circulating pump.

b) Where the installation includes more than one propulsive unit, the standby pump is not required, provided a branch pipe is fitted between the discharges of the circulating pumps of each unit.

c) In lieu of the main circulating pump, a sea inlet scoop system may be accepted, provided that an additional means is fitted to ensure the circulation of sea water to the condenser when the ship is maneuvering. Such means may be:

- an additional independent pump, or
- a connection to an available pump of sufficient capacity.

10.3.6 Cooling of other essential equipment

a) The second means of cooling required in 10.3.1 for essential equipment may consist of a connection to a ballast pump or other suitable sea water pump of sufficient capacity, provided arrangements are made against overpressure in the cooling system (see 10.7.4, item b)).

b) However, where such essential equipment is duplicate this second means may be omitted when justifications are provided as regards the propulsion and maneuvering capabilities of the ship with the cooling circuit of one set of equipment disabled.

10.4 Design of fresh water cooling systems

10.4.1 General

Fresh water cooling systems are to be designed according to the applicable requirements of 10.3.

10.4.2 Cooling systems

a) Fresh water cooling systems of essential equipment are to include at least:

- one main cooling water pump, which can be driven by the equipment
- one independently driven standby pump.

b) The standby pump may be omitted provided an emergency connection to a suitable sea water system is fitted and arranged with a suitable change-over device. Provisions against overpressure in the cooling system are to be made in accordance with 10.7.4, item b).

c) The standby pump may also be omitted in the case of redundancy of the cooled equipment.

10.4.3 Expansion tanks

Fresh water expansion tanks are to be provided with at least:

- a de-aerating device
- a water level indicator
- a filling connection
- a drain.

10.4.4 Protection of contamination by oil

Suitable means are to be provided in fresh water cooling systems comprising fuel oil or lubricating oil heat exchangers in order to detect any contamination of the water by fuel oil or lubricating oil.

If cooling water is used for heating of oil, the heating coils are to be located on the pressure side of the cooling pumps and connected by welding, with no detachable connections where mixing of oil and water may occur. Alternatively a primary and secondary system arrangement may be used.

10.5 Design of oil cooling systems

10.5.1 General

Oil cooling systems are to be designed according to the applicable requirements of 10.3.

Table 10.1: Cooling systems

Symbol convention H = High, HH = High high, G = group alarm, L = Low, LL = Low low, I = individual alarm, X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slowdown	Shutdown	Control	Stand by Start	Stop
Sea water pump pressure or flow	L	Local					
Fresh water pump pressure or flow L local	L	Local					
Level in cooling water expansion tank	L	Local					

10.5.2 Second means of cooling

The second means of cooling requested in 10.3.1 may consist of a satisfactory connection to a lubricating oil pump of sufficient capacity. Arrangements are to be made against overpressure in the cooling system.

10.6 Control and monitoring

10.6.1 Alarms are to be provided for water cooling systems in accordance with Table 10.1, in addition to the requirements stated for diesel engines in Sec 2 and for steam plants in Sec 3.

Note 1: Some departures from Table 10.1 may be accepted by the Society in the case of ships with a restricted navigation notation.

10.7 Arrangement of cooling systems

10.7.1 Sea inlets

a) At least two sea inlets complying with 2.8 are to be provided for the cooling system, one for each means of cooling required in 10.3.1.

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

c) When the second means of cooling is a spare pump, the two sea inlets are to be provided in any event, both serving the main cooling pump.

d) The sea inlets are to be low inlets, so designed as to remain submerged under all normal navigating conditions.

In general, one sea inlet is to be arranged on each side of the ship.

e) One of the sea inlets may be that of the ballast pump or of the general service pump.

10.7.2 Coolers

a) Coolers are to be fitted with isolating valves at the inlets and outlets.

b) Coolers external to the hull (chest coolers and keel coolers) are to be fitted with isolating valves at the shell.

10.7.3 Filters

a) Where propulsion engines and auxiliary engines for essential services are directly cooled by sea water, both in normal service and in emergency operating conditions, filters are to be fitted on the suction of cooling pumps.

b) These filters are to be so arranged that they can be cleaned without interrupting the cooling water supply.

10.7.4 Pumps

a) Cooling pumps for which the discharge pressure may exceed the design pressure of the piping system are to be fitted with relief valves in accordance with 2.5.

b) Where general service pumps, ballast pumps or other pumps may be connected to a cooling system, arrangements are to be made, in accordance with 2.5, to avoid overpressure in any part of the cooling system.

10.7.5 Air venting

Cocks are to be installed at the highest points of the pipes conveying cooling water to the water jackets for venting air or gases likely to accumulate therein. In the case of closed fresh water cooling systems, the cock is to be connected to the expansion tank.

11 Fuel oil systems

11.1 Application

11.1.1 Scope

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

The fuel oils used on board are to comply with Ch 1, Sec 1, 4.12.

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

Additional requirements are given:

- for independent fuel oil tanks, in App 2
- for fuel oil supply equipment forming part of engines, gas turbines, boilers, thermal heaters and incinerators, in the corresponding sections

11.2 Principle

11.2.1 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 and boilers.

b) Fuel oil systems are to be so designed as to prevent:

- overflow or spillage of fuel oil from tanks, pipes, fittings, etc.
- fuel oil from coming into contact with sources of ignition
- overheating and seizure of fuel oil.

c) Fuel oils used for engines and boilers are to have a flashpoint complying with the provisions of Ch 1, Sec 1, 4.12.

11.2.2 Availability of fuel systems

a) Fuel oil systems are to be so designed that, in the event that any one essential auxiliary of such systems becomes inoperative, the fuel oil supply to boilers and engines can be maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the ship is not impaired.

b) Fuel oil tanks are to be so arranged that, in the event of damage to any one tank, complete loss of the fuel supply to essential services does not occur.

c) Where engines and boilers are operated with heavy fuel oils, provisions are to be made to supply them with fuel oils which do not need to be heated.

11.3 General

11.3.1 Arrangement of fuel oil systems

a) In a ship in which fuel oil is used, the arrangements for the storage, distribution and utilization of the fuel oil are to be such as to ensure the safety of the ship and persons on board.

b) The provisions of 5.10 are to be complied with.

11.3.2 Provision to prevent overpressure

Provisions are to be made to prevent overpressure in any oil tank or in any part of the fuel oil system. Any relief valve is to discharge to a safe position.

11.3.3 Ventilation

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

11.3.4 Access

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

11.4 Design of fuel oil filling and transfer systems

11.4.1 General

a) A system of pumps and piping for filling and transferring fuel oil is to be provided.

b) Provisions are to be made to allow the transfer of fuel oil from any storage, settling or service tank to another tank.

11.4.2 Filling systems

a) Filling pipes of fuel oil tanks are to terminate on open deck or in filling stations isolated from other spaces and efficiently ventilated. Suitable coamings and drains are to be provided to collect any leakage resulting from filling operations.

The means shall be provided for the filling lines to prevent of possible overpressure during the bunkering operation, which could be caused by pumps from outboard filling station. For that purpose a warning label may be accepted with clearly declared design pressure of the filling lines and the local pressure gauge fitted in vicinity of the filling connection.

b) Arrangements are to be made to avoid overpressure in the filling lines which are served by pumps on board.

Where safety valves are provided for this purpose, they are to discharge to the overflow tank referred to in 9.3.3 or to other safe positions deemed satisfactory.

11.4.3 Independence of fuel oil transfer lines

Except where permitted in 11.4.4, the fuel oil transfer piping system is to be completely separate from the other piping systems of the ship.

11.4.4 Alternative carriage of fuel oil, ballast water or other liquid and dry cargo

Where certain compartments are likely to contain alternatively fuel oil, ballast water and other liquid or dry cargo, the transfer pipes supplying these compartments are to be fitted with blind flanges or other appropriate change-over devices.

11.4.5 Transfer pumps

a) At least two means of transfer are to be provided. One of these means is to be a power pump. The other may consist of:

- a standby pump, or, alternatively,
- an emergency connection to another suitable power pump.

Note 1: Where provided, purifiers may be accepted as means of transfer.

b) Where necessary, transfer pumps are to be fitted on their discharge side with a relief valve leading back to the suction of the pump or to any other place deemed satisfactory.

11.5 Arrangement of fuel oil tanks and bunkers

11.5.1 Location of fuel oil tanks

a) No fuel oil tank is to be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces.

b) Fuel oil tanks and bunkers are not to be situated immediately above boilers or in locations where they could be subjected to high temperatures, unless specially agreed by the Society. In general, the distance between fuel oil tanks and boilers is not to be less than 450 mm.

Where boilers are situated above double bottom fuel oil tanks, the distance between the double bottom tank top and the lower metallic part of the boilers is not to be less than:

- 750 mm for water tube boilers
- 600 mm for cylindrical boilers.

c) As far as practicable, fuel oil tanks are to be part of the ship's structure and are to be located outside machinery spaces of category A. Where fuel oil tanks, other than double bottom tanks, are necessarily located adjacent to or within machinery spaces of category A, at least one of their vertical sides is to be contiguous to the machinery space boundaries, and is preferably to have a common boundary with the double bottom tanks, and the area of the tank boundary common with the machinery spaces is to be kept to a minimum. Where such tanks are situated within the boundaries of machinery spaces of category A, they are not to contain fuel oil having a flashpoint of less than 60°C.

d) The location of fuel oil tanks is to be in compliance with the requirements, particularly as regards the installation of cofferdams, the separation between fuel oil tanks or bunkers and the other spaces of the ship, and the protection of these tanks and bunkers against any abnormal rise in temperature.

e) Attention is drawn to the requirements of Part 5, Ch 5 regarding the segregation of fuel bunkers from the cargo area.

11.5.2 Use of free-standing fuel oil tanks

a) In general the use of free-standing fuel oil tanks is to be avoided except on cargo ships, where their use is permitted in category A spaces.

b) For the design and the installation of independent tanks, refer to App 2.

11.5.3 Protection against oil pollution in the event of collision or grounding

a) Application

The provisions of the present requirement apply to all ships with an aggregate oil fuel capacity of 600 m^3 and above:

1) for which the building contract is placed on or after 1 August 2007; or

2) in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 February 2008; or

3) the delivery of which is on or after 1 August 2010.

The provisions of this requirement apply to all oil fuel tanks except small oil fuel tanks with a maximum individual capacity not exceeding 30 m^3, provided that the aggregate capacity of such excluded tanks is not greater than 600 m^3.

Note 1: For the purpose of application of this requirement, tanks containing oil residues (sludges) are to be considered as oil fuel tanks.

Note 2: The provisions of this requirement apply to oil fuel overflow tanks except if they are provided with an alarm for detection of oil and kept empty according to the operational procedures.

b) Maximum capacity of oil fuel tanks Individual oil fuel tanks are not to have a capacity of over 2500 m^3.

c) Oil fuel tank protection

For ships having an aggregate oil fuel capacity of 600 m^3 and above, oil fuel tanks are to be located at a sufficient distance from the bottom shell plating and from the side shell plating in accordance with the relevant provisions of MARPOL 73/78, Annex I, Regulation 12A.

d) Suction wells

Suction wells in oil fuel tanks may protube in the double bottom provided that the conditions stated in MARPOL 73/78, Annex I, Regulation 12A.10 are satisfied.

e) Valves

Lines of fuel oil piping located at a distance from the ship’s bottom or from the ship’s side less than those referred to in item c) are to be fitted with valves or similar closing devices within, or immediately adjacent to, the oil fuel tank. These valves are to be capable of being brought into operation from a readily accessible enclosed space the location of which is accessible from the navigation bridge or propulsion machinery control position without traversing exposed freeboard or superstructure decks. The valves are to close in case of remote control system failure and are to be kept closed at sea at any time when the tank contains oil fuel except that they may be opened during oil fuel transfer operations.

11.6 Design of fuel oil tanks and bunkers

11.6.1 General

Tanks such as collector tanks, de-aerator tanks etc. are to be considered as fuel oil tanks for the purpose of application of this sub-article, and in particular regarding the valve requirements.

Tanks with a volume lower than 500 l will be given special consideration by the Society.

11.6.2 Scantlings

a) The scantlings of fuel oil tanks and bunkers forming part of the ship's structure are to comply with the requirements.

b) Scantlings of fuel oil tanks and bunkers which are not part of the ship's structure are to comply with App 2. For cases which are not contained in the Tables of that appendix, scantlings will be given special consideration by the Society.

11.6.3 Filling and suction pipes

a) All suction pipes from fuel oil tanks and bunkers, including those in the double bottom, are to be provided with valves.

b) For storage tanks, filling pipes may also be used for suction purposes.

c) For fuel oil tanks which are situated higher than the double bottom tanks, the filling pipes which are connected to the tank at a point lower than the outlet of the overflow pipe, or below the top of tanks without an overflow pipe, are to be fitted with shut-off non-return valves, unless they are fitted with valves arranged in accordance with the requirements stated in 11.6.4. For filling lines entering at the top of a tank and with inside extension towards the bottom, airholes shall be drilled in the pipe near the penetration in order to avoid the siphoning effect.

d) For oil piping which is led through engine room bulkheads, shut-off valves are to be fitted in the engine room on the bulkhead, or close to, except where it is demonstrated that possible failure of the piping would not affect the availability of the fuel oil system or the safety of engine room, in general.

e) The valves requested in items a), c) and d) shall be located on the tank or bulkhead itself. However, short distance pieces of rigid construction may be accepted, the length of which is not to exceed about 1.5 D of the pipe.

11.6.4 Remote control of valves

a) Every fuel oil pipe which, if damaged, would allow oil to escape from a storage, settling or daily service tank having a capacity of 500 l and above situated above the double bottom, is to be fitted with a cock or valve directly on the tank capable of being closed from a safe position outside the space in which such tanks are situated in the event of a fire occurring in such space.

b) Such valves and cocks are also to include local control.

Indicators are to be provided on the remote and local controls to show whether they are open or shut (see 2.7.3). Where quick-closing valves are used, the indicators for remote controls may be omitted.

Note 1: For the location of the remote controls, refer to 11.10.3 item c.

c) Where fuel oil tanks are situated outside boiler and machinery spaces, the remote control required in item a) may be transferred to a valve located inside the boiler or machinery spaces on the suction pipes from these tanks.

d) In the special case of deep tanks situated in any shaft or pipe tunnel or similar space, valves are to be fitted on the tank but control in the event of fire may be effected by means of an additional valve on the pipe or pipes outside the tunnel or similar space. If such additional valve is fitted in the machinery space it is to be operated from a position outside this space.

Note 2: For cargo ships of less than 500 tons gross tonnage and non-propelled ships where the fuel oil transfer installation is designed for manual operation, suction valves from fuel oil tanks and bunkers, with the exception of daily service tanks, need not be arranged with remote controls provided they are maintained closed except during transfer operations. Such valves are, however, to be readily accessible and instruction plates are to be fitted in their vicinity specifying that they are to be kept closed except during transfer operations.

11.6.5 Drain pipes

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

11.6.6 Air and overflow pipes

Air and overflow pipes are to comply with 9.1 and 9.3.

11.6.7 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of fuel oil contained in any fuel oil tank are to be provided.

b) Sounding pipes of fuel oil tanks are to comply with the provisions of 9.2.

c) Oil-level gauges complying with 2.9.2 may be used in place of sounding pipes.

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

11.7 Design of fuel oil heating systems

11.7.1 General

a) Where heavy fuel oil is used, a suitable heating system is to be provided for storage tanks, settling tanks and service tanks in order to ensure that the fuel oil has the correct fluidity and the fuel pumps operate efficiently.

b) Where necessary for pumping purposes, storage tanks containing heavy fuel oil are to be provided with heating systems.

c) Where necessary, pumps, filters, pipes and fittings are to be provided with heat tracing systems.

d) Where main or auxiliary engines are supplied with fuel oil which needs to be heated, arrangements are to be made so that the engines can still operate if one oil heating system or the heating power source is out of action.

Such arrangements may consist of an alternative supply of the engines in accordance with 11.9.2.

11.7.2 Tank heating systems

a) Oil fuel in storage tanks are not to be heated to temperatures within 10°C below the flashpoint of the fuel oil, except that, where oil fuel in service tanks, settling tanks and any other tanks in supply system is heated, the following arrangements are to be provided:

- the length of the vent pipes from such tanks and/or a cooling device is sufficient for cooling the vapours to below 60°C, or the outlet of the vent pipes is located 3 m away from a source of ignition
- the vent pipes are fitted with flame screens
- there are no openings from the vapour space of the fuel tanks into machinery spaces (bolted manholes are acceptable)

- enclosed spaces are not to be located directly over such fuel tanks, except for vented cofferdams
- electrical equipment is not to be fitted in the vapour space of the tanks, unless it is certified to be intrinsically safe.

b) The temperature of the heating medium is not to exceed 220°C.

c) Automatic control sensors are to be provided for each heated tank to maintain the temperature of the fuel oil below the limits prescribed in item a).

For storage tanks, the manual control may be accepted subject to special consideration by the Society in each case.

d) Heated tanks are to be provided with temperature measuring systems.

e) The heating coils inlet and outlet connections at the tank are to be fitted with suitable means for closing. For steam heating coils, additional means are to be provided between tank outlet and closing device to enable testing the condensate for presence of oil.

Heating pipes and coils inside the tanks are to be of material suitable for the heated fluid.

For steel pipes, the thickness is not to be less than the values given in column 4, with Note (4), of Table 2.2.

The heating coils within the tanks are to have welded connections and are to be supported in such a way that they are not subject to non permissible stress due to vibration or thermal extension.

11.7.3 Fuel oil heaters

a) Where steam heaters or heaters using other heating media are provided in fuel oil systems, they are to be fitted with at least a high temperature alarm or a low flow alarm in addition to a temperature control, except where temperatures dangerous for the ignition of the fuel oil cannot be reached.

b) Electric heating of fuel oil is to be avoided as far as practicable.

c) However, when electric heaters are fitted, means are to be provided to ensure that heating elements are permanently submerged during operation. In all cases a safety temperature switch is to be fitted in order to avoid a surface temperature of 220°C and above. It is to be:

- independent from the automatic control sensor
- designed to cut off the electrical power supply in the event of excessive temperature
- provided with manual reset.

d) Fuel oil heaters are to be fitted with relief valves leading back to the pump suction concerned or to any other place deemed satisfactory.

11.8 Design of fuel oil treatment systems

11.8.1 General

a) Heavy fuel oils used in diesel engines are to be purified and filtered according to the engine manufacturer's requirements.

b) Provisions are to be made to avoid inadvertent entry of non-purified heavy fuel into the daily service tanks, in particular through the overflow system.

11.8.2 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) Efficient means are to be provided for draining oily water escaping from the drains.

11.8.3 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.

Note 1: On ships with a restricted navigation notation where fuel oil needs to be purified, one purifier only may be accepted.

b) Subject to special consideration by the Society, the capacity of the standby purifier may be less than that required in a), depending on the arrangements made for the fuel oil service tanks to satisfy the requirement in 11.9.2.

c) The standby purifier may also be used for other services.

d) Each purifier is to be provided with an alarm in case of failures likely to affect the quality of the purified fuel oil.

11.9 Design of fuel supply systems

11.9.1 General

a) Except otherwise specified, the propulsion machinery and auxiliary engines which are able to use the same type of fuel may be supplied from the same fuel source, provided that the following is satisfied:

- the viscosity, inlet pressure and outlet pressure required by the engine's manufacturer are to be identical
- the fuel oil preparation unit is to comply with the provisions of 11.9.4
- the capacity of fuel oil preparation unit is to be sufficient for maximum continuous rating of all supplied engines in normal working conditions
- the fuel oil lines supplying propulsion machinery and those supplying auxiliary engines are to be so arranged that a failure within one of those lines is not to render the other lines inoperable
- the arrangement to stop propulsion from outside the machinery spaces is not to affect the main electrical power supply. See also Part E for any additional class notation.

b) In ships where heavy fuel oil and marine diesel oil are used, a change-over system from one fuel to the other is to be provided. This system is to be so designed as to avoid:

- overheating of marine diesel oil
- inadvertent ingress of heavy fuel oil into marine diesel oil tanks.

c) When necessary, arrangements are to be made for cooling the marine diesel oil from engine return lines.

11.9.2 Fuel oil service tanks

a) The oil fuel service tank is an oil fuel tank which contains only the required quality of fuel ready for immediate use.

b) In general, two fuel oil service tanks for each type of fuel used on board necessary for propulsion and vital systems, or equivalent arrangements, are to be provided.

Each tank is to have a capacity of at least 8 h at maximum continuous rating of the propulsion plant and normal operating load at sea of the generator plant.

c) For "one fuel ship", where main and auxiliary engines and boiler(s) are operated with Heavy Fuel Oil (HFO), the arrangements complying with this regulation or acceptable "equivalent arrangements" shall be provided.

The arrangements complying with this regulation shall comprise at least the following tanks:

- two (2) HFO service tanks, each of a capacity sufficient for at least 8 h operation of main engine(s), auxiliary engines and auxiliary boiler(s), and
- one (1) Marine Diesel Oil (MDO) service tank for initial cold starting or repair work of engines or boilers.
- Acceptable "equivalent arrangements" shall comprise at least:
- one (1) HFO service tank with a capacity sufficient for at least 8 h operation of main engine(s), auxiliary engines and auxiliary boiler(s), and
- one (1) MDO service tank with a capacity sufficient for at least 8 h operation of main engine(s), auxiliary engines and auxiliary boiler(s), and
- for pilot burners of auxiliary boilers, if provided, an additional MDO service tank for 8 h may be required.

This arrangement only applies where main and auxiliary engines can operate with HFO under all load conditions and, in the case of main engines, during maneuvering.

d) Where main engines and auxiliary boiler(s) are operated with Heavy Fuel Oil (HFO) and auxiliary engines are operating with Marine Diesel Oil (MDO), the arrangements complying with this regulation or acceptable "equivalent arrangements" shall be provided.

The arrangements complying with this regulation shall comprise at least the following tanks:

- two (2) HFO service tanks, each of a capacity sufficient for at least 8 h operation of main engine(s) and auxiliary boiler(s), and
- two (2) MDO service tanks each of a capacity sufficient for at least 8 h operation of auxiliary engines.
- Acceptable "equivalent arrangements" shall comprise at least:
- one (1) HFO service tank with a capacity sufficient for at least 8 h operation of main engine(s) and auxiliary boiler(s), and
- two (2) MDO service tanks, each of a capacity sufficient for:
  - 4 h operation of main engine(s), auxiliary engines and auxiliary boiler(s), or
  - 8 h operation of auxiliary engines and auxiliary boiler(s).

e) The "equivalent arrangements" in items c) and d) apply, provided the propulsion and vital systems using two types of fuel support rapid fuel change over and are capable of operating in all normal operating conditions at sea with both types of fuel (MDO and HFO).

f) The arrangement of oil fuel service tanks is to be such that one tank can continue to supply oil fuel when the other is being cleaned or opened up for repair.

g) The use of a setting tank with or without purifiers, or purifiers alone, and one service tank is not acceptable as an "equivalent arrangement" to two service tanks.

Note 1: This requirement 11.9.2 need not be applied to cargo ships of less than 500 tons gross tonnage and non-propelled ships.

11.9.3 Fuel oil supply to boilers

a) In ships where boilers burning oil under pressure are installed to supply steam to the propulsion machinery or auxiliary machinery serving essential services, the fuel oil supply system is to include at least the following equipment:

- Two independently driven fuel oil service pumps, each one of a capacity sufficient to supply the boilers at their rated output. The pumps are to be arranged such that one may be overhauled while the other is in service.
- Filters or strainers fitted on the suction lines and so arranged that they can be cleaned without interrupting the fuel supply. For that purpose, two filters or strainers fitted in parallel, or one duplex type with a change over facility, may be accepted.
- Two heaters in the case that fuel oil heating is required, each one of a capacity sufficient to supply heated fuel oil to the boilers at their normal operating capacity. The heaters are to be arranged such that one may be overhauled while the other is in service.

For boiler plants where exhaust gas boiler is fitted, such that steam service essential for propulsion can be supplied without the operation of the fuel oil system of the auxiliary boiler and that other essential services are not to remain inoperable, only one fuel oil heater may be accepted.

b) The fuel oil supply system is to be capable of supplying the fuel oil necessary to generate enough steam for propulsion purposes and essential services with one unit out of action.

c) A quick-closing valve is to be provided on the fuel supply to the burners of each boiler, arranged to be easily operated in case of emergency, either directly or by remote control.

d) The fuel supply to the burners is to be capable of being automatically cut off in the event of flame failure, a low water condition, forced draft failure and loss of boiler control power.

e) Burners are to comply with requirements.

f) Where burners are provided with fuel oil flow-back to the pump suctions or other parts under pressure, nonreturn devices are to be provided to prevent fuel oil from flowing back to the burners when the oil supply is cut off.

g) Where fuel oil is supplied to the burners by gravity, a double filter satisfying the provisions of item a) is to be provided in the supply line.

h) Fuel oil supply systems are to be entirely separate from feed, bilge, ballast and other piping systems.

11.9.4 Fuel oil supply to internal combustion engines

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) Internal combustion engines intended for main propulsion are to be fitted with at least two filters, or similar devices, so arranged that one of the filters can be overhauled while the other is in use.

Note 1: Where the propulsion plant consists of:

- two or more engines, each one with its own filter, or
- one engine with an output not exceeding 375 kW, the second filter may be replaced by a readily accessible and easily replaceable spare filter.

c) Oil filters fitted in parallel are to be so arranged as to minimize the possibility of a filter under pressure being opened by mistake.

Filter chambers are to be provided with suitable means for:

- ventilating when put into operation
- de-pressurizing before being opened.

Valves or cocks used for this purpose are to be fitted with drain pipes led to a safe location.

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

e) When an fuel oil booster pump is fitted which is essential to the operation of the main engine, a standby pump, connected ready for immediate use, is to be provided.

The standby pump may be replaced by a complete spare pump of appropriate capacity ready to be connected, in the following cases:

- where two or more main engines are fitted, each with its own booster pump
- in ships having main engines each with an output not exceeding 375 kW.

f) Where fuel oils require pre-heating in order to have the appropriate viscosity when being injected in the engine, the following equipment is to be provided in the fuel oil line:

- one viscosity control and monitoring system
- two pre-heaters, one serving as a standby for the other.

g) 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.

h) De-aeration tanks fitted in pressurized fuel oil return lines are to be equipped with at least:

- an automatic venting valve or equivalent device discharging to the daily service tank or to other safe place deemed satisfactorily having a device for flow detection.
- a non-return valve in the return line from the engines.

i) For high pressure fuel oil pipes and other components which may be built-in or attached to the engine, see Ch 1, Sec 2.

Anyhow, the components of a diesel engine fuel oil 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.

j) Connections within the fuel supply and spill lines are to be constructed having regard to their ability to prevent pressurized fuel oil leaks while in service and after maintenance.

k) In multi-engine installations which are supplied from the same fuel source, means of isolating the fuel supply and spill piping to individual engines are to be provided.

The means of isolation are not to affect the operation of the other engines and shall be operable from a position not rendered inaccessible by a fire on any of the engines.

11.10 Control and monitoring

11.10.1 Monitoring

Alarms and safeguards are to be provided for fuel oil systems in accordance with Table 11.1.

Note 1: Some departures from Table 11.1 may be accepted by the Society in the case of ships with a restricted navigation notation.

11.10.2 Automatic controls

Automatic temperature control is to be provided for:

- steam heaters or heaters using other media
- electric heaters.

Table 11.1: Fuel oil systems

Symbol convention H = High, HH = High high, G = group alarm, L = Low, LL = Low low, I = individual alarm, X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slowdown	Shutdown	Control	Stand by Start	Stop
Fuel oil overflow tank level	H (1)						
Air pipe water trap level on fuel oil tanks	H (2)						
Fuel oil temperature after heaters	H (4)	Local		X (5)			
Sludge tank level local		local					
Fuel oil settling tank temperature	H (3)	local					
Fuel oil level in daily service tank	L + H (1)	local					
Fuel oil daily service tank temperature	H (3)	local					

(1) Or sightglasses on the over flow pipe, where acceptable. See 9.3.4, item d).

(2) Or alternative arrangement as per 9.1.7, item c).

(3) Applicable where heating arrangements are provided.

(4) Or low flow alarm in addition to temperature control when heated by steam or other media.

(5) Cut off of electrical power supply when electrically heated.

11.10.3 Remote controls

a) The remote control arrangement of valves fitted on fuel oil tanks is to comply with 11.6.4.

b) The power supply to:

- fuel oil burning pumps

- transfer pumps and other pumps of the fuel oil system, and
- fuel oil purifiers,

is to be capable of being stopped from a position within the space containing the pumps and from another position located outside such space and always accessible in the event of fire within the space.

c) Remote control of the valve fitted to the emergency generator fuel tank is to be in a separate location from that of other valves fitted to tanks in the engine room. “Separate location” does not mean separate spaces.

d) The positions of the remote controls are also to comply with requirements.

11.11 Construction of fuel oil piping systems

11.11.1 Materials

a) Fuel oil pipes and their valves are to be of steel or other approved material, except that the use of flexible pipes may be accepted provided they comply with 2.6.3.

b) The materials and/or their surface treatment used for the storage and distribution of oil fuel are to be selected such that they do not introduce contamination or modify the properties of the fuel. In addition to the criterion given in Table 2.1, the use of copper or zinc compounds in oil fuel distribution and utilization piping is not permitted except for small diameter pipes in low pressure systems.

11.11.2 Pipe thickness

The thickness of pipes conveying heated fuel oil, as well as their flanges, is to be calculated for a design pressure determined in accordance with Table 1.4.

11.11.3 Pipe connections

a) Connections and fittings of pipes containing fuel oil are to be suitable for a design pressure according to Table 1.3 and Table 1.4.

b) Connections of pipes conveying heated fuel oil are to be made by means of close-fitting flanges, with joints made of a material impervious to oil heated to 160°C and as thin as possible.

11.12 Arrangement of fuel oil piping systems

11.12.1 Passage of fuel oil pipes through tanks

a) Fuel pipes are not to pass through tanks containing boiler feed water, fresh water, other flammable oil or liquid cargo, unless they are contained within tunnels.

b) Transfer pipes passing through ballast tanks are to have a reinforced thickness complying with Table 2.2.

11.12.2 Passage of pipes through fuel oil tanks

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

11.12.3 Segregation of fuel oil purifiers

Purifiers for heated fuel oil are to be in accordance with requirements.

12 Lubricating oil systems

12.1 Application

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

It also applies to separate oil systems intended for the cooling of engine pistons.

12.2 Principle

12.2.1 General

a) Lubricating oil systems are to be so designed as to ensure reliable lubrication of the engines, turbines and other equipment, including electric motors, intended for propulsion:

- over the whole speed range, including starting, stopping and, where applicable, maneuvering
- for all the inclinations angles stated in Ch 1, Sec 1

b) Lubricating oil systems are to be so designed as to ensure sufficient heat transfer and appropriate filtration of the oil.

c) Lubricating oil systems are to be so designed as to prevent oil from entering into contact with sources of ignition.

12.2.2 Availability

a) Lubricating oil systems are to be so designed that, in the event that any one pump is inoperative, the lubrication of the engines and other equipment is maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the ship is not impaired.

b) An emergency lubricating system, such as a gravity system, is to be provided to ensure sufficient lubrication of equipment which may be damaged due to a failure of the pump supply.

12.3 General

12.3.1 Arrangement of lubricating oil systems

a) The arrangements for the storage, distribution and utilization of oil used in pressure lubrication systems are to be such as to ensure the safety of the ship and persons on board.

b) The provisions of 5.10 are to be complied with, where applicable.

12.3.2 Filtration

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

b) The filters provided for this purpose for main machinery and machinery driving electric propulsion generators are to be so arranged that they can be easily cleaned without stopping the lubrication of the machines.

c) The fineness of the filter mesh is to comply with the requirements of the engine or turbine manufacturers.

d) Where filters are fitted on the discharge side of lubricating oil pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

12.3.3 Purification

Where lubricating oil needs to be purified, the arrangement of the purifiers are to comply with 11.8.3.

12.3.4 Heat transfer

Lubricating oil heaters are to comply with 11.7.3.

12.4 Design of engine lubricating oil systems

12.4.1 Lubrication of propulsion engines

a) Main engines are to be provided with at least two power lubricating pumps, of such a capacity as to maintain normal lubrication with any one pump out of action.

b) In the case of propulsion plants comprising:

- more than one engine, each with its own lubricating pump, or
- one engine with an output not exceeding 375 kW, one of the pumps mentioned in a) may be a spare pump ready to be connected to the lubricating oil system, provided disassembling and reassembling operations can be carried out on board in a short time.

12.4.2 Lubrication of auxiliary engines

a) For auxiliary engines with their own lubricating pump, no additional pump is required.

b) For auxiliary engines with a common lubricating system, at least two pumps are to be provided. However, when such engines are intended for non-essential services, no additional pump is required.

12.5 Design of steam turbine lubrication systems

12.5.1 General

An alarm device is to be provided giving audible warning in the event of damage or of an appreciable reduction of the oil pressure.

12.5.2 Lubrication of propulsive turbines and turbogenerators

a) Propulsive turbines and turbogenerators are to be provided with:

- one main lubricating pump, and
- one independently driven standby pump of at least the same capacity.

b) Lubricating systems for propulsive turbines and turbogenerators are to be provided with a device which stops the steam supply to the turbines (see 12.8.1).

12.5.3 Emergency lubrication of propulsive turbines and turbogenerators

a) Propulsive turbines and turbogenerators are to be provided with an emergency lubricating system arranged for automatic start (see 12.8.1).

b) When a gravity system is provided for the purpose of a), it is to ensure an adequate lubrication for not less than six minutes and, in the case of turbogenerators, for a period at least equal to the stopping period after unloading.

c) When the emergency supply is fulfilled by means of an emergency pump, it is to be so arranged that its operation is not affected by a failure of the power supply.

d) Suitable arrangements for cooling the bearings after stopping may also be required.

12.5.4 Lubrication of auxiliary turbines intended for essential services

a) Auxiliary turbines intended for essential services are to be provided with:

- one main lubricating pump, and
- one independently driven standby pump of at least the same capacity.

b) The standby pump is to be capable of supplying satisfactory lubrication to the turbines during starting and stopping operations.

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

12.6.1 Control of controllable pitch propeller 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 item 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 375kW, 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.

12.6.2 Piston cooling

The requirements in 12.4.2 are also applicable to separate oil systems intended for the cooling of pistons.

12.7 Design of lubricating oil tanks

12.7.1 Remote control of valves

Lubricating oil tanks with a capacity of 500 litres and above are to be fitted with remote controlled valves in accordance with the provisions of 11.6.4.

The remote controlled valves need not be arranged for storage tanks on which valves are normally closed except during transfer operation, or where it is determined that an 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.

12.7.2 Filling and suction pipes

Filling and suction pipes are to comply with the provisions of 11.6.3.

12.7.3 Air and overflow pipes

Air and overflow pipes are to comply with the provisions of 9.1 and 9.3.

12.7.4 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of lubricating oil contained in the tanks are to be provided.

b) Sounding pipes are to comply with the provisions of 9.2.

c) Oil-level gauges complying with 2.9.2 may be used in place of sounding pipes.

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

12.7.5 Oil collecting tanks for engines

a) In ships required to be fitted with a double bottom, wells for lubricating oil under main engines may be permitted by the Society provided it is satisfied that the arrangements give protection equivalent to that afforded by a double bottom complying with requirements.

b) Where, in ships required to be fitted with a double bottom, oil collecting tanks extend to the outer bottom, a valve is to be fitted on the oil drain pipe, located between the engine sump and the oil drain tank. This valve is to be capable of being closed from a readily accessible position located above the working platform. Alternative arrangements will be given special consideration.

c) Oil collecting pipes from the engine sump to the oil collecting tank are to be submerged at their outlet ends.

12.8 Control and monitoring

12.8.1 In addition to the requirements stated for the diesel engines, steam turbines, gas turbines and gears, alarms are to be provided for lubricating oil systems in accordance with Table 12.1.

Note 1: Some departures from Table 12.1 may be accepted by the Society in the case of ships with a restricted navigation notation.

Table 12.1: Lubricating oil systems

Symbol convention H = High, HH = High high, G = group alarm, L = Low, LL = Low low, I = individual alarm, X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slowdown	Shutdown	Control	Stand by Start	Stop
Air pipe water level of lubricating oil tank (1)	H						
Sludge tank level		Local					

(1) See 9.1.7.

12.9 Construction of lubricating oil piping systems

12.9.1 Materials

The materials used in the storage and distribution of lubricating oil are to be selected such that they do not introduce contaminants or modify the properties of the oil. In addition to the criterion given in Tab 2.1, the use of cadmium or zinc in lubricating oil systems, where they may normally come into contact with the oil, is not permitted.

12.9.2 Air and overflow pipes

Air and overflow pipes are to comply with 9.1 and 9.3, including 5.10, as applicable.

12.9.3 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of oil contained in any lubricating oil tank are to be provided.

b) Sounding pipes of lubricating oil tanks are to comply with the provisions of 9.2.

c) Oil-level gauges complying with 2.9.2 may be used in place of sounding pipes.

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

13 Thermal oil systems

13.1 Application

13.1.1 This Article applies to all thermal oil systems involving organic liquids heated below their initial boiling temperature at atmospheric pressure by means of:

- oil fired heaters,
- exhaust gas heaters, or
- electric heaters.

13.2 Principle

13.2.1 General

Thermal oil systems are to be so designed as to:

- avoid overheating of the thermal oil and contact with air
- take into account the compatibility of the thermal oil with the heated products in case of contact due to leakage of coils or heater tubes
- prevent oil from coming into contact with sources of ignition.

13.2.2 Availability

Thermal oil systems are to be so designed that, in the event that any one essential auxiliary is inoperative, the thermal oil 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 ship is not impaired.

13.3 General

13.3.1 Limitations on use of thermal oil

a) The oil is to be used in the temperature ranges specified by the producer. The delivery temperature is, however, to be kept 50°C below the oil distillation point.

b) Thermal oil is not to be used for the direct heating of:

- accommodation,
- fresh drinking water
- liquid cargoes with flashpoints below 60°C, except where permitted in Part 5, Chapter 5.

13.3.2 Location of thermal oil system components

a) Thermal oil heaters are normally to be located in spaces separated from main and auxiliary machinery spaces, as required in Ch 1, Sec 1.

b) Where demonstrated that the arrangement required in item a) is not practical, thermal oil heaters located in machinery spaces and protected by adequate screening may be accepted, subject to special consideration by the Society for each particular case.

c) Drainage of spaces where thermal oil system components are located is to comply with 5.10.4, item f).

Note 1: For the purpose of application of Part 4, Chapter 4, spaces where thermal oil heaters are located are to be considered as machinery spaces of category A.

13.3.3 Provision for quick drainage and alternative arrangements

a) Inlet and outlet valves of oil fired and exhaust fired heaters are to be arranged for remote closing from outside the compartment where they are situated.

As an alternative, thermal oil systems are to be arranged for quick gravity drainage of the thermal oil contained in the system into a draining tank.

b) The expansion tank is to be arranged for quick gravity drainage into a draining tank.

However, where the expansion tank is located in a low fire risk space, the quick drainage system may be replaced by a remote controlled closing device for isolating the expansion tank.

The quick drainage system and the alternative closing device are to be capable of being controlled from inside and outside the space containing the expansion tank.

13.3.4 Ventilation

a) Spaces containing thermal oil heaters are to be suitably mechanically ventilated.

b) Ventilation is to be capable of being stopped from outside these spaces.

13.4 Design of thermal oil heaters and heat exchangers

13.4.1 Thermal oil heaters

Oil fired and exhaust-fired thermal oil heaters are to be designed, equipped and controlled in accordance with the requirements specified in Sec 5.

13.4.2 Heat exchangers

Heat exchangers are to be designed and equipped in accordance with the requirements specified in Ch 1, Sec 5.

13.5 Design of storage, expansion and draining tanks

13.5.1 Storage and draining tanks

a) The capacity of the storage tank is to be sufficient to compensate the losses expected in service.

b) The capacity of the draining tank is to be sufficient to collect the quantity of thermal oil contained in the system, including the expansion tank.

c) Storage and draining tanks may be combined.

13.5.2 Expansion tanks

a) The capacity of the expansion tank is to be sufficient to allow volume variations, due to temperature changes, of all the circulating oil.

b) The expansion tank is to be so designed, installed and connected to the circuit as to ensure that the temperature inside the tank remains below 50°C.

13.5.3 Drain pipes

Where provided, drains pipes of thermal oil tanks are to be fitted with self-closing valves or cocks.

13.5.4 Air pipes

a) Air pipes fitted to the expansion and drainage tanks are to be suitably sized to allow the quick gravity drainage referred to in 13.3.3.

b) The applicable requirements of 9.1 are to be complied with.

13.5.5 Overflow pipes

a) The expansion tank is to be fitted with an overflow pipe led to the drainage tank. This overflow pipe may be combined with the quick draining line provided for in 13.3.3, item b).

b) The applicable requirements of 9.3 are to be complied with.

13.5.6 Sounding pipes and level gauges

a) Sounding pipes are to comply with the provisions of 9.2.

b) Level gauges are to comply with the provisions of 2.9.2.

13.6 Design of circulation and heat exchange systems

13.6.1 Circulating pumps

At least two circulating pumps are to be provided, of such a capacity as to maintain a sufficient flow in the heaters with any one pump out of action.

However, for circulating systems supplying non-essential services, one circulating pump only may be accepted.

13.6.2 Filters

A device which efficiently filters the thermal oil is to be provided in the circuit.

In the case of essential services, the filters provided for this purpose are to be so arranged that they can be easily cleaned without stopping the thermal oil supply.

The fineness of the filter mesh is to comply with the requirements of the thermal oil heating installation manufacturer.

13.7 Control and monitoring

13.7.1 Monitoring

In addition to the requirements specified in Sec 5, for thermal heaters and heat exchangers, alarms and safeguards for thermal oil systems are to be provided.

13.7.2 Remote control

a) Remote control is to be arranged for:

- shut-off of circulating pumps
- quick drainage of the thermal oil system and expansion tank, or shut-off of the alternative devices (see 13.3.3)
- shut-off of the fuel supply to the oil fired heaters or of the exhaust gas supply to the exhaust gas heaters .

The shut-off of the exhaust gas supply may be ensured either by the engine shut down or by an exhaust gas bypass.

b) Such control is to be possible from the space containing the thermal oil heaters and from another position located outside such space.

13.8 Construction of thermal oil piping systems

13.8.1 Materials

a) Materials are to comply with the provisions of 11.11.1.

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

13.8.2 Pipe connections

a) Pipe connections are to comply with 2.4 and to be suitable for the design temperature of the thermal oil system.

b) Screw couplings of a type approved by the Society may be accepted for pipes of an outside diameter not exceeding 15 mm provided they are fitted with cutting rings or equivalent arrangements.

c) The materials of the joints are to be impervious to thermal oil.

13.9 Thermal oil piping arrangements

13.9.1 Passage of thermal oil pipes through certain spaces

a) Thermal oil pipes are not to pass through accommodation or public spaces or control stations.

b) Unless they are located in tight manifolds, provided with appropriate means of internal inspection and with a leak collecting system, heat transfer oil pipes are not allowed in main and auxiliary machinery spaces specified in Sec 1.

13.9.2 Discharge of relief valves

Relief valves are to discharge to the drain tank.

13.9.3 Provision for de-aerating

Provisions are to be made for automatic evacuation of air, steam and gases from the thermal oil system to a safe location.

14 Hydraulic systems

14.1 Application

14.1.1 Hydraulic installations intended for essential services

Unless otherwise specified, this Article applies to all hydraulic power installations intended for essential services.

The hydraulic piping arrangement is to comply also with the provisions of 5.10.

14.1.2 Hydraulic installations not serving essential services

Hydraulic power installations not serving essential services but located in spaces where sources of ignition are present are to comply with the provisions of 5.10, 14.3.2, 14.3.3, 14.4.4, 14.4.5 and 14.5.3.

14.1.3 Low pressure or low power hydraulic installations

Hydraulic power installations with a design pressure of less than 2.5 MPa and hydraulic power packs of less than 5 kW will be given special consideration by the Society.

14.1.4 Very high pressure hydraulic installations

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

14.2 General

14.2.1 Design requirements

As far as practicable, 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

a) As a rule, 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 ship is not impaired.

b) When a hydraulic power system is simultaneously serving one essential system and other systems, it is to be ensured that:

- operation of such other systems, or
- a single failure in the installation external to the essential system, is not detrimental to 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 ship and persons on board.

14.3 General

14.3.1 Definitions

a) A power unit is the assembly formed by the hydraulic pump and its driving motor.

b) An actuator is a component which directly converts hydraulic pressure into mechanical action.

14.3.2 Limitations of use of hydraulic oils

a) Oils used for hydraulic power installations are to have a flashpoint not lower than 150°C and be suitable for the entire service temperature range.

b) The hydraulic oil is to be replaced in accordance with the specification of the installation manufacturer.

14.3.3 Location of hydraulic power units

a) Generally, the hydraulic power units are to be located outside machinery spaces containing the boilers, main engine, its auxiliaries or other sources of ignition.

This applies in particular for hydraulic equipment delivering pressure over 25 bar to the following equipment:

- controllable pitch propellers or main transverse thrust units
- clutches
- turbine maneuvering steam valves
- exhaust gas valves of diesel engines or gas damper control systems
- hydraulically operated valves and pumps.

b) Where demonstrated that the arrangement required in item a) is not practical, at least the following is to be provided:

- Shields or similar protections are to be fitted around such hydraulic equipment as in order to avoid any accidental oil spray or mist to the hot surfaces or other sources of ignition.
- The low level alarm required for hydraulic tanks of these circuits is to be triggered as soon as possible.
- The automatic stop of hydraulic pumps is to be operated in the same circumstances, except where this stop can lead to propulsion stop.

14.4 Design of hydraulic pumps and accessories

14.4.1 Power units

a) Hydraulic power installations are to include at least two power units so designed that the services supplied by the hydraulic power installation can operate simultaneously with one power unit out of service. A reduction of the performance may be accepted.

b) Low power hydraulic installations not supplying essential services may be fitted with a single power unit, provided that alternative means, such as a hand pump, are available on board.

14.4.2 Pressure reduction units

Pressure reduction units used in hydraulic power installations are to be duplicated.

14.4.3 Filtering equipment

a) A device is to be fitted which efficiently filters the hydraulic oil in the circuit.

b) Where filters are fitted on the discharge side of hydraulic pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

14.4.4 Provision for cooling

Where necessary, appropriate cooling devices are to be provided.

14.4.5 Provision against overpressure

a) Safety valves of sufficient capacity are to be provided at the high pressure side of the installation.

b) Safety valves are to discharge to the low pressure side of the installation or to the service tank.

14.4.6 Provision for venting

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

14.4.7 Provision for drainage

Provisions are to be made to allow the drainage of the hydraulic oil contained in the installation to a suitable collecting tank.

14.5 Design of hydraulic tanks and other components

14.5.1 Hydraulic oil service tanks

a) Service tanks intended for hydraulic power installations supplying essential services are to be provided with at least:

- a level gauge complying with 2.9.2
- a temperature indicator
- a level switch complying with 14.6.2.

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

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 in 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

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 Indicators

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

14.6.2 Monitoring

Alarms and safeguards for hydraulic power installations intended for essential services, except steering gear, for which the provisions of Sec 12 apply, are to be provided in accordance with Table 14.1.

Note 1: Some departures from Table 14.1 may be accepted by the Society in the case of ships with a restricted navigation notation.

Note 2: Table 14.1 does not apply to steering gear.

Table 14.1: Hydraulic oil systems

Symbol convention H = High HH = High High, G = Group alarm L = Low LL = Low Low I = Individual alarm X = function is required R = Remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slowdown	Shutdown	Control	Standby Start	Stop
Pump pressure	L						
Service tank level	L (1) (2)						X(2)

(1) The low level alarm is to be activated before the quantity of lost oil reaches 100 litres or 70% of the normal volume in the tank, whichever is the less.

(2) For hydraulics cranes where no electrical system has been provided, the requirement may be waived if the level gauge, the pressure gauge and the temperature gauge indicators are always visible by the crane operator. In addition, a warning label shall be placed on the tank reminding that, prior to start any operation of the crane, the oil level is to be checked.

15 Steam systems

15.1 Application

15.1.1 Scope

This Article applies to all steam systems intended for essential and non-essential services.

Steam systems with a design pressure of 10 MPa or more will be given special consideration.

15.2 Principle

15.2.1 Availability

a) Where a single boiler is installed, the steam system may supply only non-essential services.

b) Where more than one boiler is installed, the steam piping system is to be so designed that, in the event that any one boiler is out of action, the steam supply to essential services can be maintained.

15.3 Design of steam lines

15.3.1 General

a) Every steam pipe and every connected fitting through which steam may pass is to be designed, constructed and installed such as to withstand the maximum working stresses to which it may be subjected.

b) When the design temperature of the steam piping system exceeds 400 °C, calculations of thermal stresses are to be submitted to the Society as specified in 2.3.

c) Steam connections on boilers and safety valves are to comply with the applicable requirements of Sec 5.

15.3.2 Provision against overpressure

a) If a steam pipe or fitting may receive steam from any source at a higher pressure than that for which it is designed, a suitable reducing valve, relief valve and pressure gauge are to be fitted.

b) When, for auxiliary turbines, the inlet steam pressure exceeds the pressure for which the exhaust casing and associated piping up to the exhaust valves are designed, means to relieve the excess pressure are to be provided.

15.3.3 Provision for dumping

In order to avoid overpressure in steam lines due to excessive steam production, in particular in systems where the steam production cannot be adjusted, provisions are to be made to allow the excess steam to be discharged to the condenser by means of an appropriate dump valve.

15.3.4 Provision for draining

Means are to be provided for draining every steam pipe in which dangerous water hammer action might otherwise occur.

15.3.5 Steam heating pipes

a) When heating coils are fitted in compartments likely to contain either fuel oil or liquid or dry cargoes, arrangements such as blind flanges are to be provided in order to disconnect such coils in the event of carriage of dry or liquid cargoes which are not to be heated.

b) The number of joints on heating coils is to be reduced to the minimum consistent with dismantling requirements.

15.3.6 Steam lines in cargo holds

a) Live and exhaust steam pipes are generally not to pass through cargo holds, unless special provisions are made with the Society's agreement.

b) Where steam pipes pass through cargo holds in pipe tunnels, provision is to be made to ensure the suitable thermal insulation of such tunnels.

c) When a steam smothering system is provided for cargo holds, provision is to be made to prevent spurious damage of the cargo by steam or condensate leakage.

15.3.7 Steam lines in accommodation spaces

Steam lines are not to pass through accommodation spaces, unless they are intended for heating purposes.

15.3.8 Turbine connections

a) A sentinel valve or equivalent is to be provided at the exhaust end of all turbines. The valve discharge outlets are to be visible and suitably guarded if necessary.

b) Bled steam connections are to be fitted with non-return valves or other approved means to prevent steam and water returning to the turbines.

15.3.9 Strainers

a) Efficient steam strainers are to be provided close to the inlets to ahead and astern high pressure turbines or, alternatively, at the inlets to maneuvering valves.

b) Where required by the manufacturer of the auxiliaries, steam strainers are also to be fitted in the steam lines supplying these auxiliaries.

16 Boiler feed water and condensate systems

16.1 Application

16.1.1 This Article applies to:

- feed water systems of oil fired and exhaust gas boilers
- steam drain and condensate systems.

16.2 Principle

16.2.1 General

Boiler feed water and condensate systems are to be so designed that:

- reserve feed water is available in sufficient quantity to compensate for losses
- feed water is free from contamination by oils or chlorides
- feed water for propulsion systems is suitably de-aerated.

16.2.2 Availability

a) Feed water systems are to be so designed that, in the event of failure of any one component, the steam supply to essential services can be maintained or restored.

b) Condensate systems are to be so designed that, in the event of failure of:

- one condensate pump, or
- the arrangements to maintain vacuum in the condenser, the steam supply to essential services can be maintained. Partial reduction of the propulsion capability may be accepted.

16.3 Design of boiler feed water systems

16.3.1 Number of feed water systems

a) Every steam generating system which supplies essential services is to be provided with not less than two separate feed water systems from and including the feed pumps, noting that a single penetration of the steam drum is acceptable.

b) The requirement stated in a) may be dispensed with for boilers heated exclusively by engine exhaust gases or by steam for which one feed system is considered as sufficient, provided an alternative supply of steam is available on board.

c) Each boiler is to be provided with feed regulators.

16.3.2 Feed pumps

a) The following pumps are to be provided:

- at least one main feed pump of sufficient capacity to supply the boilers under nominal conditions, and
- one standby feed pump.

b) The capacity of the standby pump may be less than that of the main feed pumps provided it is demonstrated that, taking into account the reduction of the propulsion capability, the ship remains safely operable.

c) Main feed pumps may be either independent or driven by the main turbines. The standby feed pump is to be independent.

d) In twin-screw ships in which there is only one independent feed pump, each main turbine is to be fitted with a driven pump. Where all feed pumps are independent, they are to be so arranged as to be capable of dealing with the feed water necessary to supply steam either to both turbines or to one turbine only.

e) Independent feed pumps for main boilers are to be fitted with a delivery control and regulating system.

f) Unless overpressure is prevented by the feed pump characteristics, means are to be provided which will prevent overpressure in the feed water system.

g) The pressure head of feed pumps is to take into account the maximum service pressure in the boiler as well as the pressure losses in the discharge piping. The suction head of feed pumps is to be such as to prevent cavitation as far as possible.

h) Feed pumps and pipes are to be provided with valves so arranged that any one pump can be overhauled while the boilers are operating at full load.

16.3.3 Harbour feed pumps

a) Where main turbine driven pumps are provided and there is only one independent pump, a harbour feed pump or an ejector is to be fitted in addition to provide the second means for feeding the boilers which are in use when the main turbine is not working.

b) The harbour feed pump may be used for the general service of the ship, but in no case is this pump to be used to convey liquid fuel, lubricating oil or oily water.

c) The suction pipes of the harbour feed pump from the hotwell, from reserve feed water tanks and from filters are to be fitted with non-return valves.

16.3.4 Feed water tanks

a) All ships fitted with main boilers or auxiliary boilers for essential services are to be provided with reserve feed water tanks.

b) Boilers are to be provided with means to supervise and control the quality of the feed water. Suitable arrangements are to be provided to preclude, as far as practicable, the entry of oil or other contaminants which may adversely affect the boiler.

c) Feed water tanks are not to be located adjacent to fuel oil tanks. Fuel oil pipes are not to pass through feed water tanks.

d) For main boilers, one or more evaporators are to be provided, the capacity of which is to compensate for the losses of feed water due to the operation of the machines, in particular where the fuel supplied to the boilers is atomized by means of steam.

16.3.5 Provision for de-aerating feed water

A de-aerator is to be provided to ensure the de-aeration of the feed water intended for main boilers before it enters such boilers.

16.4 Design of condensate systems

16.4.1 Condensers

a) Appropriate arrangements, such as air ejectors, are to be provided to maintain vacuum in the main condenser or restore it to the required value.

b) Cooling of the main condenser is to comply with the provisions of 10.3.5.

16.4.2 Condensate pumps

a) Condensate pumps are to include at least:

- one main condensate pump of sufficient capacity to transfer the maximum amount of condensate produced under nominal conditions, and
- one independently driven standby condensate pump.

b) The standby condensate pump may be used for other purposes.

16.4.3 Condensate observation tanks

Any condensate from the steam heating pipes provided for fuel oil tanks and bunkers, cargo tanks and fuel oil or lubricating oil heaters is to be led to an observation tank or some other device of similar efficiency located in a well-lighted and readily accessible position.

16.5 Control and monitoring

16.5.1 General

The provisions of this sub-article apply only to feed water and condensate systems intended for propulsion.

16.5.2 Monitoring

Alarms and safeguards are to be provided for feed water and condensate systems in accordance with Table 16.1.

Note 1: Some departures from Tab 16.1 may be accepted by the Society in the case of ships with a restricted navigation notation.

16.5.3 Automatic controls

Automatic level control is to be provided for:

- de-aerators,
- condensers.

16.6 Arrangement of feed water and condensate piping

16.6.1

a) Feed water pipes are not to pass through fuel oil or lubricating oil tanks.

b) Pipes connected to feed water tanks are to be so arranged as to prevent the contamination of feed water by fuel oil, lubricating oil or chlorides.

16.7 Arrangement of feed water system for shell type exhaust gas heated economizer

16.7.1 Every shell type exhaust gas heated economizer, that may be isolated from the steam piping system, is to be provided with arrangements for pre-heating and de-aeration, addition of water treatment or combination thereof to control the quality of feed water to within the manufacturer's recommendations.

Table 16.1 : Boiler feed and condensate system

Symbol convention H = High HH = High High G = Group alarm L = Low LL = Low Low I = Individual alarm X = function is required R = Remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slowdown	Shutdown	Control	Standby Start	Stop
Sea water flow or equivalent	L						
Condenser pressure	H	Local					
	HH			X			
Water level in main condenser (unless justified)	H	Local					
Feed water sanity	H	Local					
Feed water pump delivery pressure	L	Local					
						X	
Feed water tank level	L						

17 Compressed air systems

17.1 Application

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

- starting of engines,
- control and monitoring.

17.2 Principle

17.2.1 General

a) As a rule, compressed air systems are to be so designed that the compressed air delivered to the consumers:

- is free from oil and water, as necessary
- 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.

17.2.2 Availability

a) Compressed air systems are to be so designed that, in the event of failure of one air compressor or one air receiver intended for starting, control purposes or other essential services, the air supply to such services can be maintained. The filling connections of the compressed air receivers shall be fitted with a non-return valve.

b) The compressed air system for starting the main and auxiliary engines is to be arranged so that the necessary initial charge of starting air can be developed on board ship without external aid. If, for this purpose, an emergency air compressor or an electric generator is required, these units are to be powered by a hand-starting oil engine or a hand-operated compressor.

c) Where compressed air is necessary to restore propulsion, the arrangements for bringing main and auxiliary machinery into operation are to have capacity such that the starting energy and any power supplies for engine operation are available within 30 minutes of a dead ship condition.

The procedure for such condition and relevant calculation is to be submitted.

d) Where the compressed air is necessary for the air whistle or other safety services, it is to be available from two compressed air receivers. At least one of them is to be starting air receiver for main engines. The separate connection, dedicated for this purpose, is to be provided directly from the compressed air main.

17.3 Design of starting air systems

17.3.1 Air supply for starting the main and auxiliary engines

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

The number of starts refers to the engine in cold and ready-to-start condition (all the driven equipment that cannot be disconnected is to be taken into account).

A greater number of starts may be required when the engine is in warm running condition.

At least 3 consecutive starts is to be possible for each engine driving electric generators and engines for other purposes. The capacity of a starting system serving two or more of the above specified purposes is to be the sum of the capacity requirements.

b) For multi-engine propulsion plants, the capacity of the starting air receivers is to be sufficient to ensure at least 3 consecutive starts per engine. However, the total capacity is not to be less than 12 starts and need not exceed 18 starts.

Regardless of the above, for any other specific installation the number of starts may be specially considered by the Society and depending upon the arrangement of the engines and the transmission of their output to the propellers in each particular case.

17.3.2 Number and capacity of air compressors

a) Where main and auxiliary engines are arranged for starting by compressed air, two or more air compressors are to be fitted with a total capacity sufficient to supply within one hour the quantity of air needed to satisfy the provisions of 17.3.1 charging the receivers from atmospheric pressure. This capacity is to be approximately equally divided between the number of compressors fitted, excluding the emergency compressor fitted in pursuance of item c) below.

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 item a).

c) Where, for the purpose of 17.2.2, an emergency air compressor is fitted, this unit is to be power driven by internal combustion engine, electric motor or steam engine.

Suitable hand starting arrangement or independent electrical starting batteries may be accepted. In the case of small installations, a hand-operated compressor of approved capacity may be accepted.

17.3.3 Number and capacity of air receivers

a) Where main engines are arranged for starting by compressed air, at least two air receivers are to be fitted of approximately equal capacity and capable of being used independently.

b) The total capacity of air receivers is to be sufficient to provide without replenishment the number of starts required in 17.3.1. When other users such as auxiliary engine starting systems, control systems, whistle, etc. are connected to the starting air receivers, their air consumption is also to be taken into account.

Compressed air receivers are to comply with the requirements of Sec 5.

17.3.4 Air supply for starting the emergency generating set

Where starting air arrangement is one of two independent means of starting required in Sec 2, for the emergency generator, the following is to be complied with:

a) The starting air arrangement is to include a compressed air vessel, storing the energy dedicated only for starting of the emergency generator. The capacity of the compressed air available for starting purpose is to be sufficient to provide, without replenishment, at least three consecutive starts.

b) The compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a non-return valve fitted in the emergency generator space, or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard.

c) All of these starting, charging and energy storing devices are to be located in the emergency generator space and is not to be used for any purpose other than the operation of the emergency generating set.

17.4 Design of control and monitoring air systems

17.4.1 Air supply

a) The control and monitoring air supply to essential services is to be available from two sources of a sufficient capacity to allow normal operation with one source out of service.

b) At least one air vessel fitted with a non-return valve is to be dedicated for control and monitoring purposes, unless the installation is provided with local independent mechanical control and a means for communication with the wheelhouse is permanently fitted at position of local control.

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 ship.

17.4.2 Pressure control

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

17.4.3 Air treatment

In addition to the provisions of 17.8.3, arrangements are to be made to ensure cooling, filtering and drying of the air prior to its introduction in the monitoring and control circuits.

17.5 Design of air compressors

17.5.1 Prevention of excessive temperature of discharged air

Air compressors are to be so designed that the temperature of discharged air cannot exceed 95°C. For this purpose, the air compressors are to provided where necessary with:

- suitable cooling means
- fusible plugs or alarm devices set at a temperature not exceeding 120°C.

17.5.2 Prevention of overpressure

a) Air compressors are to be fitted with a relief valve complying with 2.5.3.

b) Means are to be provided to prevent overpressure wherever water jackets or casings of air compressors may be subjected to dangerous overpressure due to leakage from air pressure parts.

c) Water space casings of intermediate coolers of air compressors are to be protected against any overpressure which might occur in the event of rupture of air cooler tubes.

17.5.3 Crankcase relief valves

Air compressors having a crankcase volume of at least 0,6 m^3 are to be fitted with crankcases explosion relief valves satisfying the provisions of Sec 2.

17.5.4 Provision for draining

Air compressors are to be fitted with a drain valve.

17.6 Control and monitoring of compressed air systems

17.6.1 Monitoring

Alarms and safeguards are to be provided for compressed air systems in accordance with Table 17.1.

Note 1: Some departures from Table 17.1 may be accepted by the Society in the case of ships with a restricted navigation notation.

17.6.2 Automatic controls

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

17.7 Materials

17.7.1 Pipes and valve bodies in control and monitoring air systems and in other air systems intended for non-essential services may be made of plastic in accordance with the provisions of App 1.

17.8 Arrangement of compressed air piping systems

17.8.1 Prevention of overpressure

Suitable pressure relief arrangements are to be provided for all systems.

Table 17.1 : Compressed air systems

Symbol convention H = High HH = High High, G = Group alarm L = Low LL = Low Low I = Individual alarm X = function is required R = Remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow down	Shutdown	Control	Standby 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						

(1) Remote indication is required if starting of air compressor are remote controlled, from wheelhouse for example

17.8.2 Air supply to compressors

a) Provisions are to be made to reduce to a minimum the entry of oil into air pressure systems.

b) Air compressors are to be located in spaces provided with sufficient ventilation.

17.8.3 Air treatment and draining

a) Provisions are be made to drain air pressure systems.

b) Efficient oil and water separators, or filters, are to be provided on the discharge of compressors, and drains are to be installed on compressed air pipes wherever deemed necessary.

17.8.4 Lines between compressors, receivers and engines

All discharge pipes from starting air compressors are to be lead directly to the starting air receivers, and all starting pipes from the air receivers to main or auxiliary engines are to be entirely separate from the compressor discharge pipe system.

17.8.5 Protective devices for starting air mains

Non-return valves and other safety devices are to be provided on the starting air mains of each engine in accordance with the provisions of Sec 2.

18 Exhaust gas systems

18.1 General

18.1.1 Application

This Article applies to:

- exhaust gas pipes from engines and gas turbines
- smoke ducts from boilers and incinerators.

18.1.2 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.

18.2 Design of exhaust systems

18.2.1 General

Exhaust systems are to be so arranged as to minimize the intake of exhaust gases into manned spaces, air conditioning systems and engine intakes.

18.2.2 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 ship where a temperature rise may be dangerous.

b) The insulation of exhaust systems is to comply with the provisions of Sec 1.

18.2.3 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.

18.2.4 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 economizer, unless each exhaust pipe is provided with a suitable isolating device.

b) Smoke ducts from boilers discharging to a common funnel are to be separated to a height sufficient to prevent smoke passing from a boiler which is operating to a boiler out of action.

18.2.5 Boilers designed for alternative oil firing and exhaust gas operation

Where boilers are designed for alternative oil firing and exhaust gas operation, the exhaust gas pipe from the engine is to be fitted with an isolating device and safety arrangements to prevent the starting of the fuel oil burning units if the isolating device is not in the closed position.

18.2.6 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.

18.2.7 Control and monitoring

A high temperature alarm is to be provided in the exhaust gas manifolds of thermal oil heaters to detect any outbreak of fire.

18.3 Materials

18.3.1 General

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

18.3.2 Use of plastics

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

18.4 Arrangement of exhaust piping systems

18.4.1 Provision for thermal expansion

a) Exhaust pipes and smoke ducts are to be so designed that any expansion or contraction does not cause abnormal stresses in the piping system, and in particular in the connection with engine turboblowers.

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

18.4.2 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.

18.4.3 Flexible hoses

The use of flexible hoses in water cooled exhaust systems will be given special consideration by the Society.

18.4.4 Silencers

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

19 Oxyacetylene welding systems

19.1 Application

19.1.1 This Article applies to centralized fixed plants for oxyacetylene welding installed on ships. It may also be applied, at the discretion of the Society, to other plants using liquefied gas, such as propane.

19.2 Definitions

19.2.1 Centralised plants for oxyacetylene welding

A centralised plant for oxyacetylene welding is a fixed plant consisting of a gas bottle room, distribution stations and distribution piping, where the total number of acetylene and oxygen bottles exceeds 4.

19.2.2 Gas bottle rooms

A gas bottle room is a room containing acetylene and oxygen bottles, where distribution headers, non-return and stop valves, pressure reducing devices and outlets of supply lines to distribution stations are also installed.

19.2.3 Distribution stations

Distribution stations are adequately protected areas or cabinets equipped with stop valves, pressure regulating devices, pressure gauges, non-return valves and oxygen as well as acetylene hose connections for the welding torch.

19.3 Design of oxyacetylene welding systems

19.3.1 General

Except on pontoons and service working ships, no more than two distribution stations are normally permitted.

19.3.2 Acetylene and oxygen bottles

a) The bottles are to be tested under attendance of the Society or by a body recognised by the Society.

b) Bottles with a capacity exceeding 50 litres are not permitted.

c) Bottles supplying the plant and spare bottles are to be installed in the gas bottle room. Installation within accommodation spaces, service spaces, control stations and machinery spaces is not permitted.

d) Bottles are to be installed in a vertical position and are to be safely secured. The securing system is to be such as to allow the ready and easy removal of the bottles.

19.3.3 Piping systems

a) In general, the acetylene and oxygen piping systems are to comply with the following provisions:

- all valves and fittings as well as welding torches and associated supply hoses are to be adapted to this specific service and suitable for the conditions expected in the different parts of the system
- acetylene piping is to be of stainless steel and seamless drawn
- oxygen piping is to be of copper or stainless steel and seamless drawn
- the connections between the various pipe sections are to be carried out by means of butt welding.

  Other types of connections including threaded connections and flange connections are not permitted
- only a minimum number of unavoidable connections are permitted provided they are located in a clearly visible position.

b) High pressure lines (i.e. lines between bottles and pressure reducing devices) are to be installed inside the gas bottle room and are to comply with the following provisions:

- acetylene and oxygen piping and associated fittings are to be suitable for a design pressure of 29.5 MPa
- a non-return valve is to be installed on the connection of each acetylene and oxygen bottle to the header
- stop valves are to be provided on the bottles and kept shut when distribution stations are not working.

c) Low pressure lines (i.e. lines between pressure reducing devices and distribution stations) are to comply with the following provisions:

- for low pressure lines, black steel pipes seamless drawn could be also acceptable provided that:

  - a thickness is not less than 2,5 mm when installed in the open air

- a thickness is not less than 2,0 mm when installed indoor

- supply lines to each distribution station are to include, at the station inlet:
  - a stop valve to be kept shut when the station is not working
  - devices to protect the supply lines from back flow of gas or flame passage.

d) Safety valves are to be provided on the low pressure side of the pressure reducing devices and led to the open air at least 3 m above the deck in a safe location where no source of ignition is present.

19.4 Arrangement of oxyacetylene welding systems

19.4.1 Gas bottle rooms

a) The gas bottle room is to be located in an independent space over the highest continuous deck and provided with direct access from outside. The limiting bulkheads and decks are to be gas-tight and made of steel.

b) When the total number of gas bottles, including possible spare bottles which are not connected to the plant, does not exceed 8, acetylene and oxygen bottles may be installed in the same room. Otherwise, acetylene and oxygen bottles are to be separated by a gas-tight bulkhead.

c) The bottle room is to be adequately insulated and ventilated so that the temperature inside does not exceed 40°C. If the temperature cannot be controlled by means of natural ventilation, mechanical and independent ventilation is to be provided. Air outlets are to be led at least 3 m away from ignition sources and ventilation intakes and are to be equipped with flameproof wire gauze.

d) The gas bottle room is not to be used for other services on board. Flammable oil or gas piping, except that related to the oxyacetylene welding plant, is not to be led through this room.

Note 1: On pontoons and service working ships, gas bottles may be installed on open deck in a safe position to the satisfaction of the Society. In such case, appropriate protection is to be provided:

- for gas bottles, against sunrays and atmospheric agents, by means of watertight covers,
- for the associated valves, piping and fittings, by means of steel covers, metal grids or similar devices.

Such means of protection are to be easily removable to allow bottle removal, when necessary.

When the total number of bottles exceeds 8, acetylene bottles are to be separated from oxygen bottles.

19.4.2 Distribution stations

Distribution stations are to be located in the engine room or in the workshop, in a well-ventilated position and protected against possible mechanical damage.

Note 1: On pontoons and service working ships, distribution stations may be installed in the open air, enclosed in a cabinet with a locked door, or in controlled access areas, to the satisfaction of the Society.

19.4.3 Piping

a) Piping is not to be led through accommodation or service spaces.

b) Piping is to be protected against any possible mechanical damage.

c) In way of deck or bulkhead penetrations, piping is to be suitably enclosed in sleeves so arranged as to prevent any fretting of the pipe with the sleeve.

19.4.4 Signboards

Signboards are to be posted on board the ship in accordance with Table 19.1.

Table 19.1: Signboards

Location of the signboard	Signboard to be posted
in the gas bottle room	diagram of the oxyacetylene plant
	"no smoking"
in way of: • bottle stop valves • distribution station stop valves	"to be kept shut when distribution stations are not working"
in way of the pressure reducing devices	indication of the maximum allowable pressure at the pressure reducing device outlet
in way of the safety valve discharge outlet	"no smoking"

20 Certification, inspection and testing of piping systems

20.1 Application

20.1.1 This Article defines the certification and workshop inspection and testing programme to be performed on:

- the various components of piping systems
- the materials used for their manufacture.

20.2 Type tests

20.2.1 Type tests of flexible hoses and expansion joints

a) For the flexible hoses or expansion joints which are to comply with 2.6, relevant type approval tests are to be carried out on each type and each size.

b) The flexible hose or an expansion joint subjected to the tests is to be fitted with their connections.

c) Type approval tests are to be carried out in accordance with the prototype test programmes required in 2.6.4, including, but not limited to, the scope of testing specified within Table 20.1.

Exemptions from this requirement may be granted in accordance with 2.6.4, item d).

Testing of the expansion joints of large diameter used on exhaust gas lines, except for those which are fitted directly on engines, may be limited to pressure test.

20.2.2 Type tests of air pipe closing appliances

Type approval tests are to be carried out on each type and size of air pipe closing device, in accordance with Table 20.2.

Table 20.1: Type tests to be performed for flexible hoses and expansion joints

Test	Non-metallicmaterial	Metallic material
Bursting test	X	X
Fire-resistance test	X (1)	
Vibration test	X (2)	X (2)
Flexibility test	X (3)	X
Elastic deformation test	NR	X
Cyclic expansion test	X	X (4)
Resistance test	X (5)	X (5)
Hydraulic pressure impulse test without flexing	X (7)	
Hydraulic pressure impulse test with flexing	X (6) (8)	
Pliable test (bend test)		X (9)
Cycle test		X (9)
U bend test		X (9)
Cantilever bend test		X (9)
Pressure test with burst test and elongation test		X (9)

(1) where used in flammable oil and sea water systems (ref. ISO 15540; ISO 15541)

(2) where fitted to engines, pumps, compressors or other sources of high vibrations

(3) where conveying low temperature fluids

(4) for piping systems subjected to expansion cycles

(5) internal to the conveyed fluid and external to UV

(6) for constructions with wire reinforcements

(7) ref. ISO 6803

(8) ref. ISO 6802

(9) ref. ISO 10380.

Note 1: X = required, NR = not required.

Table 20.2: Type tests to be performed for air pipe closing appliances

Test to be performed	Type of air closing appliance	
	Float type	Other types
Tightness test [(1)]	X	X
Flow characteristic determination [(2)]	X	X
Impact test of floats	X	
Pressure loading test of floats	X [(3)]	

(1) The tightness test is to be carried out during immerging/ emerging in water, in the normal position and at an inclination of 40 degrees.

(2) Pressure drop is to be measured versus flow rate using water.

(3) Only for non-metallic floats.

Note 1: X = required

20.3 Testing of materials

20.3.1 General

a) Detailed specifications for material tests are given in part 2, Materials and Welding.

b) Requirements for the inspection of welded joints are given in part 2, Materials and Welding.

c) The requirements of this Article do not apply to piping systems subjected to low temperatures, such as cargo piping of liquefied gas carriers.

20.3.2 Tests for materials

a) Where required in Table 20.3, 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.

20.4 Hydrostatic testing of piping systems and their components

20.4.1 General

Pneumatic tests are to be avoided wherever possible.

Where such testing is absolutely necessary in lieu of the hydraulic pressure test, the relevant procedure is to be submitted to the Society for acceptance prior to testing.

Table 20.3: Inspection and testing at works for piping systems and their components

Item **(5)**		Tests for the materials **(1)**		Inspections and tests for the product **(1)**		
		Tests required **(7)**	Type of material certificate **(2)**	During manufacturing (NDT)	After completion	Type of product certificate **(2)**
Raw pipes	class I, ND ≥ 50 class II, ND ≥ 100	[20.3.2]	C **(3)**	[3.6.2], [3.6.3] **(4)**	[20.4.3]	C **(3)**
	class I, ND < 50 class II, ND < 100		W		[20.4.3]	W **(3)**
Valves and fittings	class I, ND ≥ 50 class II, ND ≥ 100	[20.3.2]	C	[3.6.2], [3.6.3] **(4)**	[20.4.3]	C **(3)**
	class I, ND < 50 class II, ND < 100		W		[20.4.3]	C **(3)**
Pipes, valves and fittings connected to: • the ship side • the collision bulkhead • fuel oil and lubricating oil tanks and under static pressure	ND ≥ 100	[20.3.2]	C **(3)**	[3.6.2], [3.6.3] **(4)**	[20.4.3], b)	C **(3)**
	ND < 100		W			
Flexible hoses and expansion joints		[20.3.2]	W		[20.4.6]	C **(3)**
Pumps and compressors within piping systems covered by Sections of Part C, Chapter 1 **(9)**	when belonging to a class I piping system	[20.3.2]	C **(3)**		[20.4.5]	C **(3)**
	when belonging to a class II piping system	[20.3.2]	W		[20.4.5]	C **(3)**
	bilge and fire pump	[20.3.2]	W		[20.4.5] [20.5.1] a)	C **(3)**
	feed pumps for main boilers	[20.3.2]	C **(3)**	[3.6.2], [3.6.3] **(4)** **(8)**	[20.4.5] [20.5.1] b)	C **(3)**
	forced circulation pumps for main boilers	[20.3.2]	C **(3)**		[20.4.5]	C **(3)**
	when belonging to one of the following class III piping systems if design pressure exceeds 0,35 MP: • boiler feed water or forced circulating • fuel oil or other flammable oil • compressed air	[20.3.2]	W		[20.4.5]	C **(3)**
	when belonging to other class III piping systems				[20.4.5]	W

Item (5)		Tests for the materials (1)		Inspections and tests for the product (1)		
		Tests required (7)	Type of material certificate (2)	During manufacturing (NDT)	After completion	Type of product certificate (2)
Centrifugal separators					[20.5.2]	C (3)
Prefabricated pipeline	classes I and II with ND ≥ 65 or t ≥ 10			[3.6.2], [3.6.3] (6)	[20.4.2]	C (3)
	classes I and II with ND < 65 or t < 10			[3.6.2], [3.6.3] (6)	[20.4.2]	W
	class III where design pressure exceeds 0,35 MP, as follows: • steam pipes and feed water pipes • compressed air pipes • fuel oil or other flammable oil pipes				[20.4.2]	W

(1) [x.y.z] = test required, as per referent regulation. In general, the material are to comply with 2.1.2

(2) C = class certificate; W = works' certificate.

(3) or alternative type of certificate, depending on the Survey Scheme.

(4) if of welded construction.

(5) ND = Nominal diameter of the pipe, valve or fitting, in mm.

Class of piping systems is to be determined in accordance with 1.5.2.

(6) for welded connections.

(7) where required by the table, material tests are to be carried out for the components subject to pressure, such as valve body, pump and compressor casings, etc. They are also to be carried out for the assembling bolts of feed water pumps and forced circulating pumps serving main boilers. Requirements for material testing are detailed in part II, Materials and Welding.

(8) for main parts, before assembling.

(9) for other pumps and compressors, see additional Rules relevant for related system.

20.4.2 Hydrostatic pressure tests of piping

a) Hydrostatic pressure tests are to be carried out to the Surveyor's satisfaction for:

- all class I and II pipes and their integral fittings
- all steam pipes, feed water pipes, compressed air pipes, and fuel oil and other flammable oil pipes with a design pressure greater than 0,35 MPa and their associated integral fittings.

b) These tests are to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

Note 1: Classes of pipes are defined in 1.5.2.

c) Pressure testing of small bore pipes (less than 15 mm) may be waived at the discretion of the Surveyor, depending on the application.

d) Where the design temperature does not exceed 300°C, the test pressure is to be equal to 1.5p.

e) Where the design temperature exceeds 300°C, the test pressure is to be as follows:

- for carbon and carbon-manganese steel pipes, the test pressure is to be equal to 2 p
- for alloy steel pipes, the test pressure PH is to be determined by the following formula, but need not exceed 2 p:

$p_H = 1.5p(K_{100}/K_T)$

where:

K_{100} : Permissible stress for 100°C, as stated in Table 2.7

K_T : Permissible stress for the design temperature, as stated in Table 2.7.

Note 2: Where alloy steels not included in Table 2.7 are used, the permissible stresses will be given special consideration.

f) Where it is necessary to avoid excessive stress in way of bends, branches, etc., the Society may give special consideration to the reduction of the test pressure to a value not less than 1.5p. The membrane stress is in no case to exceed 90% of the yield stress at the testing temperature.

g) 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 over speed device.

h) Hydrostatic testing may be carried out after assembly on board of the piping sections under the conditions stated in Sec 14.

For pressure tests of plastic pipes after assembly on board, see App 1.

20.4.3 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 recognized by the Society, at a pressure not less than 1,5 times the design pressure P defined in 1.3.2.

b) Valves and distance pieces intended to be fitted on the ship side below the load waterline are to be subjected to hydrostatic tests under a pressure not less than 0,5 MPa.

c) The shells of appliances such as heaters, coolers and heat exchangers which may be considered as pressure vessels are to be tested under the conditions specified in Sec 5.

d) The nests of tubes or coils of heaters, coolers and heat exchangers are to be submitted to a hydraulic test under the same pressure as the fluid lines they serve.

e) For coolers of internal combustion engines, see Sec 2.

20.4.4 Hydrostatic tests of fuel oil bunkers and tanks not forming part of the ship's structure

Fuel oil bunkers and tanks not forming part of the ship's structure are to be subjected to a hydrostatic test under a pressure corresponding to the maximum liquid level in such spaces or in the air or overflow pipes, with a minimum of 2,40 m above the top. The minimum height is to be 3,60 m for tanks intended to contain fuel oil with a flashpoint below 60°C.

20.4.5 Hydrostatic tests of pumps and compressors

a) Cylinders, covers and casings of pumps and compressors are to be subjected to a hydrostatic test under a pressure at least equal to the test pressure pH , in MPa, determined by the following formulae:

- $pH = 1.5\ p$ where $p \leq 4$
- $pH = 1.4\ p + 0.4$ where $4 < p \leq 25$
- $pH = p + 10.4$ where $p > 25$

where:

p : Design pressure, in MPa, as defined in 1.3.2.

p_H is not to be less than 0.4 MPa.

b) While satisfying the condition stated in a), the test pressure for centrifugal pumps driven by steam turbines is not to be less than 1.05 times the maximum pressure likely to be recorded with closed discharge at the operating

speed of the over speed device.

c) Intermediate coolers of compressors are to undergo a hydrostatic test under a pressure at least equal to the pressure pH defined in a). When determining pH , 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.

d) 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.

e) For air compressors and pumps driven by internal combustion engines, see Sec 2.

20.4.6 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. For the expansion joints, or flexible hose used on exhaust gas lines, see 2.6.4, d).

b) During the test, the flexible hose or expansion joint is to be repeatedly deformed from its geometrical axis.

20.5 Testing of piping system components during manufacturing

20.5.1 Pumps

a) Bilge and fire pumps are to undergo a performance test.

b) Rotors of centrifugal feed pumps for main boilers are to undergo a balancing test.

20.5.2 Centrifugal separators

Centrifugal separators used for fuel oil and lubricating oil are to undergo a running test, normally with a fuel water mixture.

20.6 Inspection and testing of piping systems

20.6.1 The inspections and tests required for piping systems and their components are summarized in Table 20.3.

Section 12 Steering Gear

1 General

1.1 Scope

1.1.1 The requirements of this section apply to the design and construction of steering gear.

1.1.2 Whilst the requirements of this section are considered to meet the relevant regulations of the Safety of Life at Sea 1974 and applicable amendments, attention should be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

1.1.3 Consideration will be given to other cases, or to other arrangements which are equivalent to those required by the Rules.

1.2 Definitions

1.2.1 Steering gear control systems means the equipment by which orders are transmitted from the navigating bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

1.2.2 Main steering gear means the machinery, rudder actuator(s), the steering gear power units, if any, and ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions.

1.2.3 Steering gear power unit means:

a) in the case of electric steering gear, an electric motor and its associated electrical equipment;

b) in the case of electro hydraulic steering gear, an electric motor and its associated electrical equipment and connected pump;

c) in the case of other hydraulic steering gear, a driving engine and connected pump.

For the purposes of non-traditional steering arrangements such as azimuthing propellers, water jets, etc, the above definitions may be applied as appropriate. The steering gear power unit relates to the equipment for changing the direction of thrust and does not include those for generating the thrust.

1.2.4 Auxiliary steering gear means the equipment other than any part of the main steering gear necessary to steer the ship in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose.

1.2.5 Power actuating system means the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with 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.

1.2.6 Maximum ahead service speed means the greatest speed which the ship is designed to maintain in service at sea at her deepest seagoing draught.

1.2.7 Rudder actuator means the component(s) which converts directly hydraulic pressure into mechanical action to move the rudder.

1.2.8 Maximum working pressure means the expected pressure in the system when steering gear is operated to comply with 2.1.2(b).

1.2.9 Declared steering angle limits in the case of non-traditional steering arrangements such as azimuthing propellers, water jets, etc. are the operational limits in terms of maximum steering angle, or equivalent, according to manufacturers guidelines for safe operation, also taking into account the vessel's speed or propeller torque/speed or other limitation. The "declared steering angle limits" are to be declared by the directional control system manufacturer for each ship specific nontraditional steering mean. Ship's maneuverability tests, such as Res. MSC.137 (76) are to be carried out with steering angles not exceeding the declared steering angle limits.

1.3 Installation

1.3.1 The steering gear is to be secured to the seating by fitted bolts, and suitable chocking arrangements are to be provided. The seating is to be of substantial construction.

1.4 Steering gear compartment

1.4.1 The steering gear compartment is to be:

a) Readily accessible and, as far as practicable separated from machinery spaces;

b) Provided with suitable arrangements to ensure working access to steering gear machinery and controls. These arrangements are to include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

1.5 Plans

1.5.1 Before starting construction, all relevant plans and specifications are to be submitted for approval in triplicate.

1.5.2 These plans should give details of scantlings and materials of the steering gear together with proposed rated torque and all relief valve settings.

1.6 Materials

1.6.1 All the steering gear components the rudder stock and/or components of other steering arrangements for directional control are to be of sound and reliable construction to the Surveyor's satisfaction of ACS.

1.6.2 All components transmitting mechanical forces to the rudder stock are to be tested according to the requirements of Part 2.

1.6.3 Ram; cylinders; pressure housing of rotary vane type actuators; hydraulic power piping; valves; flanges and fittings; and 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, duly tested in accordance with the requirements of Part 2.

In general, such material is not to have an elongation of less than 12 percent nor a tensile strength in excess of 650 N/mm^2. The use of ductile (nodular) iron castings will be acceptable provided the material has an elongation of not less than 12 percent.

1.7 Rudder, rudder stock, vanes, tiller and quadrant

1.7.1 For the requirements regarding rudder, rudder stock, See Part.3, Ch. 2, Sec13.

1.7.2 All components transmitting mechanical forces to the rudder stock are to have a strength of at least equivalent to the rudder stock in way of the tiller. The resultant equivalent stress, σ_e, caused by the transmission of rudder torque, Q_r, in tillers, vanes and other power transmitting components is not to exceed 118/k [N/mm²], i.e.

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \le 118/k \qquad [\mathrm{N/mm^2}]$$

where,

σ_e = The combined equivalent stress, [N/mm²]

σ = The bending stress, [N/mm²]

τ= The torsional shear stress, [N/mm²]

k = Material factor for the component under consideration as defined below

$$k = \left(235/\sigma_y\right)^e$$

with e = 0.75 for $\sigma_y > 235$ [N/mm²]

= 1.0 for $\sigma_y \le 235$ [N/mm²]

Q_r = The rudder torque [N-m].

1.7.3 The section modulus 'Z' [cm³] and the sectional area 'A' [cm²] of the tiller arms is not to be less than the following:

$$Z = 0.012 Q_r \left(1 - x/R\right) k \qquad [\mathrm{cm^3}]$$

$$A = 2.0 k (Q_r / R) 10^{-4} \qquad [\mathrm{cm^2}]$$

where,

R = The distance [m] from the point of application of the effort on the tiller to the centre of rudder stock; and

x = The distance [m] from the section under consideration to the centre of the rudder stock.

1.7.4 The boss may be fitted on the rudder stock by shrinking with/without key or may be of the split type. The ratio between the mean of outer and inner diameters of the boss is to be not less than 1.75 and the height of the boss is not to be less than the inner diameter of the boss.

1.7.5 Coefficient of friction for shrink fitting is to be taken as 0.15.

1.7.6 In case of split type boss, the total number of joining bolts is to be at least 4. The distance of the centre of the bolts from the centre of the rudder stock is generally to be 1.15du and the thickness of the coupling flange is to be at least 1.1 times the required bolt diameter. The thickness of shim to be fitted between two halves before machining is to be 0.0015du. The diameter of the coupling bolt, db is to be not less than:

$$d_b = 0.60 \frac{du\sqrt{k}}{\sqrt{(nks)}} \qquad \text{[mm]}$$

where,

du = The rudder stock diameter [mm] in way of the tiller calculated in accordance with Part.3, Ch.2, Sec.14;

n = Total number of joining bolts.

k = Material factor for the bolts.

ks = Material factor for the rudder stock material.

1.7.7 The dimensions of the key are to comply with the requirements of Part.3, Ch.2, Sec.14.

1.7.8 Where higher tensile bolts are used on bolted tillers and quadrants, the yield and ultimate tensile stresses of the bolt material are to be stated on the plans submitted for approval, together with full details of the methods to be adopted to obtain the required setting-up stress.

Where patent nuts or systems are used, the manufacturer's instructions for assembly should be adhered to.

1.7.9 In bow rudders having a vertical locking pin operated from the deck above, positive means are to be provided to ensure that the pin can be lowered only when the rudder is exactly central. In addition, an indicator is to be fitted at the deck to show when the rudder is exactly central.

1.8 Mechanical steering gear

1.8.1 Steel-wire rope, chain and other mechanical systems, when these are used for rudder stock diameters of 120 [mm] and less but excluding allowance for strengthening in ice, will be specially considered. In general the breaking strength of rods/chains etc. is not to be less than:

Breaking strength = $6NQ_r/R$

Where R is defined in 1.7.3.

2 Performance

2.1 Requirements for traditional type of steering gears

2.1.1 Unless the main steering gear comprises of two or more identical power units, in accordance with 2.1.4 or 8.1.1, every ship is to be provided with a main steering gear and an auxiliary steering gear in accordance with the requirements of the Rules. The main steering gear and the auxiliary steering gear are to be so arranged that the failure of one of them will not render the other one inoperative.

The rudder stock diameters mentioned in 2.1.2c), 2.1.3c) and 6.1.1 are to be taken as having been calculated for mild steel with yield strength of 235 [N/mm^2].

2.1.2 The main steering gear and rudder stock are to be:

a) Of adequate strength and capable of steering the ship at maximum ahead speed which is to be demonstrated in accordance with 7.2;

b) Capable of putting the rudder over from 35°on one side to 35° on the other side with the ship at its deepest seagoing draught and running ahead at maximum ahead service speed and under the same conditions, from 35° on either side to 30° on the other side in not more than 28 seconds;

c) Operated by power where necessary to meet the requirements of (b) and in any case when the Rules, excluding strengthening for navigation in ice, require a rudder stock over 120 [mm] diameter in way of the tiller (See 2.1.1); and

d) So designed that they will not be damaged at maximum astern speed; however, this design requirement need not be proved by trials at maximum astern speed and maximum rudder angle.

2.1.3 The auxiliary steering gear is to be:

a) Of adequate strength and capable of steering the ship at navigable speed and of being brought speedily into action in an emergency:

b) Capable of putting the rudder over from 15 on one side to 15 on the other side in not more than 60 seconds with the ship 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

c) Operated by power where necessary to meet the requirements of (b) and in any case when the Rules, excluding strengthening for navigation in ice, require a rudder stock over 230 [mm] diameter in way of the tiller. (See 2.1.1).

2.1.4 Where the main steering gear comprises two or more identical power units, an auxiliary steering gear need not be fitted, provided that :

a) In a passenger ship, the main steering gear is capable of operating the rudder as required by 2.1.2 (b) while any one of the power units is out of operation;

b) In a cargo ship, the main steering gear is capable of operating the rudder as required by 2.1.2 (b) while operating with all power units;

c) The main steering gear is arranged so 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 is regained.

2.1.5 Main and auxiliary steering gear power units are to be:

a) Arranged to re-start automatically when power is restored after a power failure;

b) Capable of being brought into operation from a position on the navigating bridge. 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 navigating bridge;

c) Arranged so that transfer between units can be readily effected.

2.1.6 Steering gear, other than of the hydraulic type, will be accepted provided the standards are considered equivalent to the requirements of this article.

2.1.7 Manually operated gears are only acceptable when the operation does not require an effort exceeding 16 [kgf] under normal conditions.

2.2 Requirements for non-traditional (azimuthing propellers, water jets, etc.) type of steering gears:

2.2.1 For a ship fitted with multiple steering systems, such as but not limited to azimuthing propulsors or water jet propulsion systems, the requirement in 2.1.1 is considered satisfied if each of the steering systems is equipped with its own steering gear.

2.2.2 The main steering arrangements for ship directional control are to be:

a) of adequate strength and capable of steering the ship at maximum ahead speed which is to be demonstrated in accordance with 7.2;

b) capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 2.3°/s with the ship running ahead at maximum ahead service speed;

c) for all ships, operated by power;

d) so designed that they will not be damaged at maximum astern speed

2.2.3 The auxiliary steering arrangements for ship directional control are to be:

a) of adequate strength and capable of steering the ship at navigable speed and of being brought speedily into action in an emergency:

b) capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed, of not less than 0.5°/s; with the ship running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater;

and

c) for all ships, operated by power where necessary to meet the requirements of 2.2.3.b and in any ship having propulsive power of more than 2,500 kW per thruster unit.

2.2.4 Where the main steering arrangements for ship directional control comprises two or more identical power units, auxiliary steering arrangements need not be fitted, provided that:

a) In a passenger ship, the main steering arrangements are capable of operating the ship's directional control system as required by paragraph 2.2.2.b while any one of the power units is out of operation;

b) In a cargo ship, the main steering arrangements are capable of operating the ship's directional control system as required by paragraph 2.2.2.b while operating with all power units;

c) The main steering arrangements are arranged so that after a single failure in its piping or in one of the power units the defect can be isolated so that steering capability can be maintained or speedily regained.

2.2.5 In a ship fitted with multiple steering systems, such as but not limited to azimuthing propulsors or water jet propulsion systems, an auxiliary steering gear need not be fitted, provided that :

a) In a passenger ship, each of the steering systems is fitted with two or more identical power units, capable of satisfying the requirements in 2.2.2.b while any one of the power units is out of operation;

b) In a cargo ship, each of the steering systems is fitted with one or more identical power units, capable of satisfying the requirements in 2.2.2.b while operating with all power units;

c) Each of the steering systems is arranged so that after a single failure in its piping or in one of the power units, ship steering capability (but not individual steering system operation) can be maintained or speedily regained (e.g. by the possibility of positioning the failed steering system in a neutral position in an emergency, if needed).

2.2.6 Main and auxiliary steering gear power units are to be:

a) Arranged to re-start automatically when power is restored after a power failure;

b) Capable of being brought into operation from a position on the navigating bridge. 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 navigating bridge;

c) Arranged so that transfer between units can be readily effected.

2.3 Other requirements

2.3.1 Where the steering gear is so arranged that more than one power system can be simultaneously operated, the risk of hydraulic locking caused by a single failure is to be considered.

2.3.2 A means of communication is to be provided between the navigating bridge and the steering gear compartment.

2.3.3 Power-operated steering gears are 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 synchronized with the gear itself and not with the steering gear control.

3 Construction and Design

3.1 General

3.1.1 Rudder actuators other than those covered by 8.3 and 9 are to be designed in accordance with the relevant requirement of Sec 5 for Class 1 pressure vessels (notwithstanding any exemptions for hydraulic cylinders).

3.1.2 Accumulators, if fitted, are to comply with the requirements of Sec 5.

3.1.3 The welding details and welding procedures are to be approved. 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.

3.1.4 The construction is to be such as to minimize local concentration of stress.

3.1.5 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 2.1.2 (b) taking into account any pressure which may exist in the lower pressure side of the system. Fatigue criteria may be applied for the design of piping and components, taking into account pulsating pressures due to dynamic loads (See 9).

3.1.6 The permissible primary general membrane stress is not to exceed the lower of the following values

$\sigma B/A$ or $\sigma Y/B$

where,

σB = specified minimum tensile strength of material at ambient temperature

σY = specified minimum yield stress or 0.2 percent proof stress of the material, at ambient temperature

A and B are given by the following table :

	Wrought Steel	Cast Steel	Nodular Cast Iron
A	3.5	4	5
B	1.7	2	3

3.2 Components

3.2.1 Special consideration is to be given to the suitability of any essential component which is not duplicated. Any such essential component is to, where appropriate, utilize anti-friction bearings such as ball bearings, roller bearings or sleeve bearings which are to be permanently lubricated or provided with lubrication fittings.

3.2.2 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.

3.2.3 Oil seals between non-moving parts, forming part of the external pressure boundary, should be of the metal type or of an equivalent type.

3.2.4 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.

3.2.5 Piping, joints, valves, flanges and other fittings are to comply with the requirements of Sec 5 for Class I piping systems components.

The design pressure is to be in accordance with 3.1.5.

3.2.6 Hydraulic power operated steering gears are to be provided with the following :-

a) Arrangements to maintain the cleanliness of the hydraulic fluid taking into consideration the type and design of the hydraulic system;

b) A fixed storage tank having sufficient capacity to recharge at least one power actuating system including the reservoir, where the main steering gear is required to be power operated. The storage tank is to be permanently connected by piping in such a manner that the hydraulic systems can be readily recharged from a position within the steering gear compartment and provided with a contents gauge.

3.3 Valve and relief valve arrangement

3.3.1 For all vessels with non-duplicated actuators, isolating valves are to be fitted at the connection of pipes to the actuators, and are to be directly fitted to the actuator. Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

3.3.2 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.

3.3.3 Relief valves, for protecting any part of the hydraulic system which can be isolated, required by 3.3.2 are to comply with the following:

a) The setting pressure is not to be less than 1.25 times the maximum working pressure.

b) The minimum discharge capacity of the relief valve(s) is not to be less than 110 percent of the total capacity of the pumps which can deliver through it (them). Under such conditions the rise in pressure is not to exceed 10 percent of the setting pressure.

In this regard, due consideration is to be given to extreme foreseen ambient conditions in respect of oil viscosity.

3.4 Flexible hoses

3.4.1 Hose assemblies approved by ACS may be installed between two points where flexibility is required but are not subjected to torsional deflection (twisting) under normal operating conditions. In general, the hose should be limited to the length necessary to provide for flexibility and for proper operation of machinery.

3.4.2 Hoses should be high pressure hydraulic hoses according to recognized standards and suitable for the fluids, pressures, temperatures and ambient conditions in question.

3.4.3 Burst pressure of hoses is not to be less than four times the design pressure.

4 Steering Control Systems

4.1 General

4.1.1 Steering gear control is to be provided:

a) For the main steering gear, both on the navigating bridge and in the steering gear compartment;

b) Where the main steering gear is arranged according to 2.1.4, by two independent control systems, both operable from the navigating bridge. This does not require duplication of the steering wheel or steering lever. Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted, except in a tanker, chemical tanker or gas carrier of 10,000 tons gross and upwards;

c) For the auxiliary steering gear, in the steering gear compartment and, if power operated, it is to be also operable from the navigating bridge and is to be independent of the control system for the main steering gear;

d) Where the steering gear is so arranged that more than one control system can be simultaneously operated, the risk of hydraulic locking caused by a single failure is to be considered.

4.1.2 Any main and auxiliary steering gear control system operable from the navigating bridge is to comply with the following:

a) Means are to be provided in the steering gear compartment for disconnecting any control system operable from the navigating bridge from the steering gear it serves;

b) The system is to be capable of being brought into operation from a position on the navigating bridge.

4.1.3 The angular position of the rudder is to :

a) If the main steering gear is power operated, be indicated on the navigating bridge. The rudder angle indication is to be independent of the steering gear control system.

b) Be recognizable in the steering gear compartment.

4.1.4 Appropriate operating instructions with a block diagram showing the change-over procedures for steering gear control systems and steering gear actuating systems are to be permanently displayed in the wheelhouse and in the steering gear compartment.

4.1.5 Where the system failure alarms for hydraulic lock are provided, appropriate instructions are to be placed on the navigating bridge to shut down the system at fault.

4.2 Mechanical, hydraulic and electrical independency and failure detection and response of steering control systems

4.2.1 Two independent steering gear control systems are to be provided and so arranged that a mechanical, hydraulic or electrical failure in one of them will not render the other one inoperative.

4.2.2 The term “steering gear control system” as defined in 1.2.1 is to be understood as “steering control system” covering “the equipment required to control the steering gear power actuating system”.

4.2.3 Separation of control systems and components

4.2.3.1 General

Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles are to be separated as far as practicable. Where physical separation is not practicable, separation may be achieved by means of a fire retardant plate.

4.2.3.2 Steering wheel or steering lever

All electric components of the steering gear control systems are to be duplicated. This does not require duplication of the steering wheel or steering lever.

4.2.3.3 Steering mode selector switch

If a joint steering mode selector switch (uniaxial switch) is employed for both steering gear control systems, the connections for the circuits of the control systems are to be divided accordingly and separated from each other by an isolating plate or by air gap.

4.2.3.4 Follow-up amplifier

In the case of double follow-up control, the amplifiers are to be designed and fed so as to be electrically and mechanically separated. In the case of non follow-up control and follow-up control, it is to be ensured that the follow-up amplifiers are protected selectively

4.2.3.5 Additional control systems

Control circuits for additional control systems, e.g. steering lever or autopilot are to be designed for all pole disconnection.

4.2.3.6 Feed-back units and limit switches

The feed-back units and limit switches, if any, for the steering gear control systems are to be separated electrically and mechanically connected to the rudder stock or actuator separately.

4.2.3.7 Hydraulic control components

Hydraulic system components in the power actuating or hydraulic servo systems controlling the power systems of the steering gear (e.g. solenoid valves, magnetic valves) are to be considered as part of the steering gear control system and are to be duplicated and separated.

Hydraulic system components in the steering gear control system that are part of a power unit may be regarded as being duplicated and separated when there are two or more separate power units provided and the piping to each power unit can be isolated.

4.2.4 Failure detection and response of control systems

4.2.4.1 Failure detection

4.2.4.1.1 The most probable failures that may cause reduced or erroneous system performance are to be detected and are to consider at least the following:

i) Power supply failure

ii) Loop failures in closed loop systems, both command and feedback loops (normally short circuit, broken connections and earth faults)

iii) If programmable electronic systems are used:

1. data communication errors

2. computer hardware and software failures

iv) Hydraulic locking considering order given by steering wheel or lever.

All failures detected are to initiate an audible and visual alarm on the navigation bridge.

Hydraulic locking is to be always warned individually, unless system design makes manual action unnecessary.

“Hydraulic locking” includes all situations where two hydraulic systems (usually identical) oppose each other in such a way that it may lead to loss of steering. It can either be caused by pressure in the two hydraulic systems working against each other or by hydraulic “by-pass” meaning that the systems puncture each other and cause pressure drop on both sides or make it impossible to build up pressure.

4.2.4.1.2 Alternatively to 4.2.4.1.1 ii) and iii) depending on the rudder characteristic, critical deviations between rudder order and response are to be indicated visually and audibly as steering failure alarm on the navigating bridge.

The following parameters are to be monitored:

Direction : Actual rudder position follows the set value

Delay : Rudder’s actual position reaches set position within acceptable time limits

Accuracy : The end actual position is to correspond to the set value within the design offset tolerances

4.2.4.1.3 System response upon failure

The most probable failures, e.g. loss of power or loop failure is to result in the least critical of any new possible conditions.

5 Electric Power Circuits, Electric Control Circuits, Monitoring and Alarms

5.1 Electric power circuits

5.1.1 Short circuit protection, an overload alarm and in the case of polyphase circuits, an alarm to indicate single phasing is to be provided for each main and auxiliary motor circuit. Protective devices are to operate at not less than twice the full load current of the motor or circuit protected and are to allow excess current to pass during the normal accelerating period of the motors.

5.1.2 Circuits obtaining their power supply via an electronic converter, e.g. for speed control and which are limited to full load current for continuous rating are exempt from the requirement to provide protection against excess current of magnitude as given in 5.1.1.

The overload alarm is to be set to a value for which the electronic converter is designed considering the most severe condition of operation.

5.1.3 Indicators for running indication of each main and auxiliary motor are to be installed on the navigating bridge and at a suitable main machinery control position.

5.1.4 Each electric or electrohydraulic steering gear comprising one or more power units is to be served by at least two exclusive circuits fed directly from the main switchboard; however one of the circuits may be supplied through the emergency switchboard. An auxiliary electric or electrohydraulic steering gear may be connected to one of the circuits supplying the main steering gear. The circuits supplying an 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.

5.1.5 The circuits, required by 5.1.4, are to be separated throughout their length as widely as is practicable.

5.1.6 In ships of less than 1600 tons gross, if an auxiliary steering gear is not electrically powered or is powered by an electric motor primarily intended for other services, the main steering gear may be fed by one circuit from the main switchboard. Consideration would be given to other protective arrangements than described in 5.1.1, for such a motor primarily intended for other services.

5.2 Electric control circuits

5.2.1 Electric control systems are to be independent and separated as far as is practicable throughout their length.

5.2.2 Each main and auxiliary electric control system which is operable from the navigating bridge is to comply with the following:-

a) It is to be served with electric power by a separate circuit supplied from the associated steering gear power circuit, from a point within the steering gear compartment, or directly from the same section of the switchboard busbars, main or emergency, to which the associated steering gear power circuit is connected.

b) Each separate circuit is to be provided with short circuit protection only.

5.3 Monitoring and alarms

5.3.1 All alarms associated with steering gear faults are to be indicated on the navigating bridge and in accordance with the alarm system specified in Ch.3. The alarms are to be both audible and visual.

6 Emergency Power

6.1 General

6.1.1 Where the rudder stock is required to be over 230 [mm] diameter in way of the tiller (See 2.1.1), excluding strengthening for navigation in ice, an alternative power supply, sufficient at least to supply the steering gear power unit which complies with the requirements of 2.1.3 and also its associated control system and the rudder angle indicator, is to be provided automatically, within 45 seconds, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power is to be used only for this purpose.

6.1.1 In the case of non-traditional steering arrangements such as azimuthing propellers, waterjets, etc where the propulsion power exceeds 2500kW per thruster unit, an alternative power supply, sufficient at least to supply the steering arrangements which complies with the requirements of clause 2.2.3.b and also its associated control system and the steering system response indicator, are to be provided automatically, within 45s, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power is to be used only for this purpose.

The above requirement is relevant for the steering systems having a certain proven steering capability attained due to vessel speed regardless of availability of propulsion power.

6.1.2 In every ship of 10,000 tons gross and upwards, the alternative power supply is to have a capacity for at least 30 minutes of continuous operation and in any other ship for at least 10 minutes.

6.1.3 Where the alternative power source is a generator, or an engine driven pump, starting arrangements are to comply with the requirements relating to the starting arrangements of the emergency generators.

7 Testing and Trials

7.1 Testing

7.1.1 The requirements of the Rules relating to the testing of Class I pressure vessels, piping, and related fittings including hydraulic testing apply.

7.1.2 After installation on board the vessel the steering gear is to be subjected to the required hydrostatic and running tests.

7.1.3 Each type of power unit pump is to be subjected to a type test. The type test is to be for a duration of not less than 100 hours, the test arrangements are to be such that the pump may run in idling conditions, and at maximum delivery capacity at maximum working pressure.

During the test, idling periods are to be alternated with periods at maximum delivery capacity at maximum working pressure. The passage from one condition to another should occur at least as quickly as on board. During the whole test no abnormal heating, excessive vibration or other irregularities are permitted.

After the test, the pump is to be opened out and inspected. Type tests may be waived for a power unit which has been proven to be reliable in marine service.

7.2 Trials

7.2.1 The steering gear is to be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of the Rules have been met. The trial is to include the operation of the following :-

i) The steering gear; including demonstration of the performances required by 2.1.2 (b) and 2.1.3 (b). In order to demonstrate this ability, the trials may be conducted in accordance with Section 6.1.5.1 of ISO 19019:2005 “Seagoing vessels and marine technology – Instructions for planning, carrying out and reporting sea trials”. On all occasions when trials are conducted with the vessel not at the deepest seagoing draught the loading condition can be accepted on the basis of the following:

- either the rudder is fully submerged (at zero speed waterline) and the vessel is in an acceptable trim condition, or,
- the rudder load and torque at the trial loading condition have been reliably predicted and extrapolated to the full load condition,

The above is to be to the satisfaction of ACS.

In any case for the main steering gear trial, the speed of ship should correspond to the maximum continuous revolution of main engine and maximum design pitch.

ii) The steering gear power units, including transfer between steering gear power units;

iii) The isolation of one power actuating system, checking the time for regaining steering capability;

iv) The hydraulic fluid recharging system;

v) The emergency power supply required by 6.1.1;

vi) The steering gear controls, including transfer of control and local control;

vii) The means of communication between the steering gear compartment and wheelhouse, also the engine room, if applicable;

viii) The alarm and indicators;

ix) Where the steering gear is designed to avoid hydraulic locking, this feature is to be demonstrated.

Test of items (iv), (vii), (viii) and (ix) may be effected at the dockside.

8 Additional Requirements

8.1 For tankers, chemical tankers or gas carriers of 10,000 tons gross and upwards and every ship of 70,000 tons gross and upwards

8.1.1 The main steering gear is to comprise two or more identical power units complying with the provisions of 2.1.4.

8.2 For tankers, chemical tankers or gas carriers of 10,000 tons gross and upwards

8.2.1 Subject to 8.3, the following are to be complied with:

a) The main steering gear is to be so arranged that in the event of loss of steering capability due to a single failure in any part of one of the power actuating systems of the main steering gear, excluding the tiller, quadrant or components serving the same purpose, or seizure of rudder actuators, steering capability is to be regained in not more than 45 seconds after the loss of one power actuating system.

b) The main steering gear is to comprise either;

i) two independent and separate power actuating systems, each capable of meeting the requirements of 2.1.2 (b); or

ii) at least two identical power actuating systems which, acting simultaneously in normal operation are capable of meeting the requirements of 2.1.2(b).

Where necessary to comply with these requirements, inter- connection of hydraulic power actuating systems is to be provided. Loss of hydraulic fluid from one system is to be capable of being detected and the defective system automatically isolated so that the other actuating system or systems remain fully operational.

c) Steering gears other than of the hydraulic type are to achieve equivalent standards.

8.3 For tankers, chemical tankers or gas carriers of 10,000 tons gross and upwards but of less than 100,000 tonnes deadweight

8.3.1 Solutions other than those set out in 8.2.1 which need not apply the single failure criterion to the rudder actuator or actuators, may be permitted provided that an equivalent safety standard is achieved and that:

a) Following loss of steering capability due to a single failure of any part of the piping system or in one of the power units, steering capability is regained within 45 seconds;

and

b) Where the steering gear includes only a single rudder actuator special consideration is given to stress analysis for the design including fatigue analysis and fracture mechanics analysis, as appropriate, the material used, the installation of sealing arrangements and the testing and inspection and provision of effective maintenance. In consideration of the foregoing, regard will be given to the "guidelines" in .sub-section 9.

8.3.2 Manufacturers of steering gear who intend their product to, comply with the requirements of the 9 are to submit full details when plans are forwarded for approval.

9 Guidelines for the Acceptance of Non-duplicated Rudder Actuators for Tanker, Chemical Tankers or Gas Carriers of 10,000 tons gross and upwards but of less than 100,000 tonnes Deadweight

9.1 Materials

9.1.1 Parts subject to internal hydraulic pressure or transmitting mechanical forces to the rudderstock are to be made of duly tested ductile materials complying with recognized standards.

Materials for pressure retaining components are to be in accordance with recognized pressure vessel standards. These materials are not to have an elongation less than 12 percent nor a tensile strength in excess of 650 [N/mm^2].

9.2 Design

9.2.1 Design pressure The design pressure should be assumed to be at least equal to the greater of the following :-

a) 1.25 times the maximum working pressure to be expected under the operating conditions required in 2.1.2(b).

b) The relief valves(s) setting.

9.2.2 Analysis In order to analyze the design the following are required :

a) The manufacturers of rudder actuators should submit detailed calculations showing the suitability of the design for the intended service.

b) A detailed stress analysis of the pressure retaining parts of the actuator should be carried out to determine the stresses at the design pressure.

c) Where considered necessary because of the design complexity or manufacturing procedures, a fatigue analysis and fracture mechanics analysis may be required. In connection with these analyses, all foreseen dynamic loads should be taken into account.

Experimental stress analysis may be required in addition to, or in lieu of, theoretical calculations depending upon the complexity of the design.

9.2.3 Dynamic loads for fatigue and fracture mechanics analysis The assumptions for dynamic loading for fatigue and fracture mechanics analysis where required by 3.1.5, 8.3 and 9.2.2 are to be submitted for appraisal. Both the cases of high cycle and cumulative fatigue are to be considered.

9.2.4 Allowable stresses For the purpose of determining the general scantlings of parts of rudder actuators subject to internal hydraulic pressure the allowable stresses should not exceed:

$\sigma_m \leq f$

$\sigma_p \leq 1.5\ f$

$\sigma_b \leq 1.5\ f$

$\sigma_p + \sigma_b \leq 1.5\ f$

$\sigma_m + \sigma_b \leq 1.5\ f$

where,

σ_m = equivalent primary general membrane stress

σ_p = equivalent primary local membrane stress

σ_b = equivalent primary bending stress

f = the lesser of $\sigma B/A$ or $\sigma Y/B$

σB = specified minimum tensile strength of material at ambient temperature

σY = specified minimum yield stress or 0.2 percent proof stress of material at ambient temperature

A and B are as follows :

	Wrought Steel	Cast Steel	Nodular Cast Iron
A	4	4.6	5.8
B	2	2.3	3.5

9.2.5 Burst test Pressure retaining parts not requiring fatigue analysis and fracture mechanics analysis may be accepted on the basis of a certified burst test and the detailed stress analysis required by 9.2.2 need not be provided. The minimum bursting pressure should be calculated as follows :-

$$P_b = PA\frac{\sigma B_a}{\sigma B}$$

where,

P_b = minimum bursting pressure

P = design pressure as defined in 9.2.1

A = as defined in 9.2.4

σB_a = actual tensile strength

σB = tensile strength as defined in 9.2.4.

9.3 Construction details

9.3.1 General

The construction should be such as to minimize local concentration of stress.

9.3.2 Welds

a) The welding details and welding procedures should be approved.

b) All welded joints within the pressure boundary of a rudder actuator or connection parts transmitting mechanical loads should be full penetration type or of equivalent strength.

9.3.3 Oil seals Oil seals forming part of the external boundary are to comply with 3.2.3 and 3.2.4.

9.3.4 Isolating valves Isolating valves are to be fitted at the connection of the pipes to the actuator, and should be directly mounted on the actuator.

9.3.5 Relief valves Relief valves for protecting the rudder actuator against over-pressure as required in 3.3.2 are to comply with the following:

a) The setting pressure is not to be less than 1.25 times the maximum working pressure expected under operating conditions required by 2.1.2(b).

b) The minimum discharge capacity of the relief valve(s) is to be not less than 110 percent of the total capacity of all pumps which provide power for the actuator. Under such conditions the rise in pressure should not exceed 10 percent of the setting pressure.

In this regard due consideration should be given to extreme foreseen ambient conditions in respect of oil viscosity.

9.4 Non-destructive testing

9.4.1 The rudder actuator should be subjected to suitable and complete non-destructive testing to detect both surface flaws and volumetric flaws. The procedure and acceptance criteria for non-destructive testing should be in accordance with requirements of recognized standards. If found necessary, fracture mechanics analysis may be used for determining maximum allowable flaw size.

9.5 Testing

9.5.1 Tests, including hydrostatic test, of all pressure parts at 1.5 times the design pressure should be carried out.

9.5.2 When installed on board the ship, the rudder actuator should be subjected to a hydrostatic test and a running test.

Section 13 Construction of Refrigerating Installations

1 General

1.1 Scope

The Rules for construction of refrigerating installations apply to all the machinery and hull equipment of the refrigerating installation serving the ship's cargo.

The safety requirements of these Rules also apply to refrigerating installations not subject to classification, provision refrigerating installations and air conditioning refrigerating installations.

1.2 Definitions

Within the meaning of these Rules, refrigerating installations on seagoing ships are:

Cargo refrigerating installations for the refrigeration of insulated cargo holds, and Container refrigerating installations for the refrigeration of insulated containers.

The provisions assume that the refrigerating installations are permanently installed and belong to the ship.

1.3 Deviation from the Rules

For the fulfillment of its function as a Classification Society, ACS reserves the right to modify or amend the present Rules as it deems necessary in the light of practical experience, technical progress and special design requirements.

1.4 Documents for approval

1.4.1 For refrigerating installations which are built under the supervision and in accordance with the Rules of the Society, each of the following documents is to be submitted to the Society in due time:

a) A description of the refrigerating installations to provide the information necessary for the classification of refrigerating installations.

b) A calculation of the cooling load as evidence of the adequate capacity of the installation.

c) A general arrangement plan of the refrigerating installation with details of the ventilation of the refrigerating machinery spaces.

d) Drawings of the compressors (longitudinal and transverse sections) and a workshop drawing of the crankshaft or rotors.

e) Performance data of the compressors.

f) Drawings of all vessels and equipment under refrigerant pressure, e.g. condensers, evaporators and oil separators as well as brine tanks and air coolers, together with details of the materials used.

g) Diagrams showing the layout of refrigerant, brine and cooling water pipelines with details of the wall thicknesses and materials of the pipes.

h) Drawings showing the arrangement and equipment of the refrigerated spaces or container holds with details of air circulation and space ventilation including air ducts and temperature measuring equipment.

i) Drawings showing the type and design of the defrosting system.

j) Drawings showing the type and execution of the insulation used for the refrigerated spaces and air ducts, with details of the insulation of hatches, doors, covers for scuppers and bilges, thermal bridges, and refrigerant and brine piping.

k) Drawings of the bilge pumping and drainage facilities in refrigerated and air cooler spaces.

l) Drawings and descriptions of electrical temperature- monitoring systems with details covering the extent of the system, the arrangement, number and coordination of the measuring points and instruments, measuring ranges, accuracy, wiring etc.

m) Description of automatic control systems.

1.4.2 Where the ship's machinery is not built under the supervision of ACS or of another recognized Classification Society, plans of the power supply plant have also to be submitted together with the documents relating to the refrigerating installation.

1.4.3 Re-submission of drawings of installation components for which the drawings have already been approved by the Society is not required.

1.5 Testing of materials and components

The selection and testing of materials is subject to the Rules for Metallic Materials stated in Part 2.

1.5.1 All components under refrigerant pressure are required to undergo material testing as a matter of principle. Subject to the requirements in 7.3., components of refrigerant compressor casings, refrigerant circulating pumps and refrigerant valves and fittings are exempted from this Rules.

1.5.2 Materials tests are to be performed on the crankshafts of reciprocating compressors and the rotors of screw compressors with a calculated journal diameter of more than 50 mm. Works certificates are sufficient for journal diameters of ≤ 50 mm.

1.5.3 The Society reserves the right to extend material testing to other important plant components.

2 Installation Design and Rating

2.1 Electrical power supply

At least two generating sets must be available for supplying power to refrigerating installations. The capacity of the generators is to be such that, in addition to other requirements:

2.1.1 When all the generators are in operation, the total power requirements of the refrigerating installation can be satisfied, the "total power requirements" being the installed electrical load of the refrigerating installation;

2.1.2 In the event of the failure or shutdown of any one generator, all refrigerating machinery, with the exception of the stand-by sets, can be operated at full load.

2.2 Number of refrigerating units

2.2.1 At least two complete refrigerating units are to be installed for each refrigerating installation or autonomous group thereof.

2.2.2 For the purpose of the present Rules a refrigerating unit comprises one refrigerant compressor and driving engine, one condenser and, in the case of indirect evaporation with brine as cooling medium, one brine cooling evaporator.

2.2.3 Where several compressors operate in a closed circuit with one condenser and, where installed, one brine cooling evaporator, this also counts as one refrigerating unit.

2.2.4 Where only two refrigerating units are installed, each compressor must be capable of working with each condenser and, where applicable, with each brine cooling evaporator.

2.3 Refrigerating capacity

2.3.1 The refrigerating capacity of the installation is to be rated in such a way that, should any particular refrigerating unit fail, the required refrigerated space or refrigerated container temperatures can be maintained.

The required refrigerated space or refrigerated container temperature is the temperature on which the cooling load calculation is based and which is certified in the Refrigerating Installation Certificate.

2.3.2 For refrigerating installations comprising a large number of refrigerant compressors or refrigerating units, the number of compressors or units to be provided as stand-by capacity is to be agreed with the Society. This stand-by capacity shall not, however, be less than 10 %.

2.3.3 If the liquefied refrigerant is subcooled with the aid of additional devices, e.g. heat exchangers, another such device with the same capacity is to be provided as a stand-by.

This stand-by unit may be dispensed with if it is demonstrated to the Society that the available compressors for refrigerating spaces or containers, including the stand-by compressor, are capable of maintaining the stipulated temperatures in the refrigerated spaces or refrigerated containers without subcooling the refrigerant.

2.4 Factors affecting plant rating

2.4.1 The calculation of the required refrigerating capacity is to be based on a seawater temperature of at least 32°C and on an ambient air temperature of at least 40 °C with 55 % relative humidity unless other values are agreed with the Society in consideration of special trade.

2.4.2 The calculation shall likewise be based on the area enveloping the refrigerated spaces on the inside of the insulation, where such spaces are adjacent to non-cooled spaces, cooled spaces at higher temperatures, the ambient air or seawater.

2.4.3 Where a ship is equipped with several mutually independent refrigerating installations, the calculation of the refrigerating capacity required is to be based on each group of spaces belonging to one installation considered in isolation and as though surrounded by non-cooled spaces, if no limiting qualifications are to be entered on the Refrigerating Installation Certificate.

2.5 Calculation of refrigerating capacity for fruit cargo

2.5.1 The calculation of the necessary refrigerating capacity is required to prove that the rating of the installation is sufficient to cool down the cargo within a reasonable period of time. All refrigerating units and pumps, including the stand-by sets, may be in operation during the cooling-down period.

2.5.2 Under steady operating conditions, allowance is to be made for the fan heat generated with the maximum air circulation and for the simultaneous introduction of a reasonable quantity of fresh air.

2.6 Calculation of refrigerating capacity for deep-frozen cargo

2.6.1 For deep-frozen cargo, no arrangements need normally be made for cooling down the cargo.

2.6.2 Unless otherwise agreed, the introduction of fresh air can be dispensed with. The fan heat to be applied in the calculation may be based on a reduced air circulation where this is intended for the deep frozen cargo.

2.7 Automation

2.7.1 Automated refrigerating installations are to be so equipped that they can also be operated with manual control.

2.7.1.1 Input units and actuating devices are to be type-tested..

2.7.2 Steps must be taken to prevent the temperature in the inlet ducts from falling below the minimum permitted level.

2.7.3 For the following faults alarm systems are to be installed which actuate an alarm at a position which is constantly manned.

2.7.3.1 Temperature of return air or air in space exceeding the maximum permitted level. A temperature instrument on the bridge may be accepted as an alternative.

2.7.3.2 Failure of circulating fans.

2.7.3.3 Permitted level exceeded in bilges or bilge wells of refrigerated spaces.

2.7.3.4 Suction pressure of refrigerant below permitted level.

2.7.3.5 Condensation pressure of refrigerant above permitted level.

2.7.3.6 Lubricating oil pressure below required level.

2.7.4 If any of the faults in 2.7.3.4, 2.7.3.5 and 2.7.3.6 occur, the installation must automatically shut down.

2.8 Plant of novel design

Refrigerating installations differing in design from those which have already proved suitable in service on board ship are subject to the Society's special approval.

For such installations, the Society may impose special requirements as to the extent of the documentation to be submitted for approval and the scope of the tests.

3 Refrigerants

3.1 Classification

Refrigerants are classified as follows:

3.1.1 Approved refrigerants, Group 1

Incombustible refrigerants without significant hazard to human health, e.g.:

R22	Chlordifluormethane	CHCIF2
R134a	Tetrafluorethane	CH2F-CF3
R404A	R125/143a/134a(44/52/4%)	
R407A	R32/125/134a(20/40/40 %)	
R407B	R32/125/134a(10/70/20 %)	
R407C	R32/125/134a(23/25/52 %)	
R410A	R32/125 (50/50 %)	
R507	R125/143a (50/50 %)	

With these refrigerants the danger of asphyxiation is, however, to be borne in mind.

3.1.2 Approved refrigerants, Group 2

Toxic or caustic refrigerants and those which, when mixed with air, have a lower explosion limit of at least 2,5 % by volume.

R717	Ammonia	NH3

Ammonia may not be used in refrigerating plants operating with direct evaporation. In addition, the regulations imposed by the competent authorities of the country of registration are to be observed.

3.1.3 Refrigerants which are not approved, Group 3

Refrigerants which, when mixed with air, have a lower explosion limit of less than 3.5 % by volume, e.g. ethane, ethylene.

3.2 Working pressures

3.2.1 For the more common refrigerants, the allowable working pressures PB (design pressures PR) are laid down in Table 3.1.

Table 3.1

Refrigerant	Working pressures [bar]	
	High-pressure side (HP)	Low-pressure side (LP)
R22	22,5	17,0
R134a	13,9	10,6
R404A	25,0	19,7
R407A	25,2	19,8
R407B	26,5	20,9
R407C	23,9	18,8
R410A	33,6	26,4
R507	25,6	20,2
R717 (NH_3)	24,0	17,5

For other refrigerants, the design pressures PR are determined by the pressure at the bubble point at a temperature of 55 °C on the high-pressure side and at a temperature of 45 °C on the low-pressure side.

3.2.2 Within the meaning of these Rules, the low pressure side of the plant includes all parts exposed to the evaporation pressure of the refrigerant. However, these parts are also subject to the design pressure for the high-pressure side if (e.g. for hot gas defrosting) a switch-over of the system can subject them to high pressure.

Medium-pressure vessels of two-stage plants form part of the high-pressure side.

3.3 Storage or reserve supplies of refrigerants

3.3.1 On board ship, reserve supplies of refrigerants may be stored only in steel bottles approved for this purpose by the competent authorities of the country of registration.

3.3.2 The level of filling of these bottles must be suitable for tropical conditions.

3.3.3 Bottles containing refrigerant are to be securely anchored in an upright position and protected against overheating.

3.3.4 Bottles containing refrigerant may be stored only in well ventilated spaces specially prepared for this purpose or in refrigerating machinery spaces.

3.3.5 On ships where (with due regard for the provisions of 4.) there is no refrigerating machinery space and the refrigerating machinery is installed in the main or auxiliary engine room, the Society may permit exceptions to 3.3.4 in the case of refrigerants belonging to Group 1. The storage bottles immediately required for replenishing the system, up to a maximum of 20 % of the total refrigerant charge, may then be kept in the main or auxiliary engine room.

4 Refrigerating Machinery Spaces

4.1 Definition

Within the meaning of these Rules, refrigerating machinery spaces are spaces separated by bulkheads from other service spaces and housing refrigerating machinery and the associated equipment.

4.2 Installation of refrigerating machinery

Even if not installed in specially designated spaces, refrigerating machinery is to be installed in such a way that sufficient space is left for operation, servicing and repair.

4.3 Equipment and accessories

4.3.1 Refrigeration systems using ammonia in charges exceeding 25 kg are to be installed in refrigerating machinery spaces separated by gastight divisions from other ship spaces and service rooms.

4.3.2 Regardless of the type of refrigerant used, the doors of refrigerating machinery spaces shall not give access to living quarters or corridors in the accommodation area. The doors must open outwards and be self-closing.

4.3.3 Where refrigeration systems operate with ammonia spaces accommodating the refrigerating machinery are to be equipped as follows:

a) Spaces must be provided with at least two access doors located as far as possible from each other.

b) Type-tested gas detectors are to be fitted. Visual and audible signals must be provided outside and inside the room. The alarm is to be linked to the general machinery alarm system and is to trip an individual alarm on the bridge as well as in the engine control room.

c) Equipment for producing water screens is to be fitted above the entrances to refrigerating machinery spaces. Provision must be made for actuating this equipment from outside the refrigerating machinery space. The actuating device shall not be located in the immediate vicinity of the entrances.

Where water sprinklers are additionally mounted in the refrigerating machinery spaces themselves, these are to be permanently installed and must also be capable of being actuated from outside.

The spray nozzles of sprinkler systems are to be suitably distributed in the refrigerating machinery space. Due attention is to be paid to electrical machinery and equipment. The spray nozzles shall be capable of covering as large an area as possible with fine water droplets.

d) The electrical consumers in the refrigerating machinery spaces must be capable of being switched off, independently of the forced ventilation system, by a central switch located outside the room.

4.3.4 Provision must be made for the bilge pumping or drainage of refrigerating machinery spaces.

Where refrigeration systems are operated with ammonia, the refrigerating machinery spaces must not be drained into the open wells or bilges of other spaces.

4.3.5 The electrical equipment of refrigerating machinery spaces is subject to the provisions of Chapter 2.

4.3.6 In the case of refrigeration systems which use ammonia, suitable protective clothing, as well as goggles and breathing apparatus for at least two people must be provided outside the refrigerating machinery space close to the access door.

Additional national requirements, e.g. self-contained air breathing apparatus and protective clothes are to be observed.

4.4 Ventilation

4.4.1 Refrigerating machinery spaces must be provided with a suitably arranged forced ventilation system.

With Group 1 refrigerants, at least the exhaust air is to be conveyed into the open air independently of other space ventilation ducting. The inlet ducting shall not be connected to the ventilation system serving the accommodation spaces.

4.4.2 Where ammonia is used, the ventilation of the refrigerating machinery space shall be independent from ventilation systems of other spaces in the ship. The ventilation system is to be of exhaust type.

4.4.3 Within the ship, the exhaust air ducts of fans serving refrigerating machinery spaces are to be gastight.

The exhaust air must be conveyed in such a way as to prevent entrance of gas into other ship spaces.

4.4.4 Provision must be made for starting and stopping the fans of refrigerating machinery spaces from outside the spaces in question. The switches are to be clearly marked.

4.4.5 The rating of forced ventilation systems is subject to the following rules:

a) For refrigerating machinery spaces with Group 1 refrigerants, forced ventilation is required which ensures at least 30 changes of air per hour.

b) For refrigerating machinery spaces in which ammonia is used as refrigerant, the minimum capacity of the fan is to be determined by the formula:

$$\dot{V} = 60\sqrt[3]{m^2}$$

However, the number of air changes per hourshall not be less than 40.

In the above formula:

$\dot{V}$ is capacity of fan [m^3/h]

m is charge of refrigerant in system [kg].

In the case of refrigeration systems using ammonia installed in rooms with an effective sprinkler system, the minimum required capacity of the fans indicated above may be reduced by 20 %.

5 Refrigerant Compressors

5.1 General

5.1.1 Where the compressors are electrically driven, the motors and other items of electrical plant must comply with the requirements of Chapter 2.

5.1.2 Other compressor drives (diesel engines, turbines) must comply with the Rules for Seagoing Ships, Chapter 2.

5.2 Reciprocating compressors

5.2.1 Shaft journal and crank pin diameters are to be determined as follows:

$$d_k = 0.115 \sqrt[3]{D^2 p_c C_1 C_w (0.3H + fL)}$$

where:

d_k = minimum journal or pin diameter [mm]

D = cylinder diameter [mm]

p_c = design pressure PR [bar] according to Table 3.1, working pressures on the high-pressure side

H = piston stroke [mm]

L = center distance between two main bearings [mm], where one crank is located between two main bearings; L is to be replaced by L_1 = 0.85 L, where two cranks at different angles are located between two main bearings, and by $L_2 = 0.95 \cdot L$, where two or three connecting rods are located next to each other on one crank

f = factor relating to cylinder arrangement [–]:

= 11.0, where the cyl. are in line

= 1.2, where the cyl. make an angle of 90° V or W arrangement

= 1.5, where the cyl. make an angle of 60° V or W arrangement

= 1.8, where the cyl. make an angle of 45° V or W arrangement

C_1 = coefficient according to Table 5.1 [–]

z = number of cylinders [–]

C_w = material factor according to Table 5.2 or Table 5.3 [–]

R_m = minimum tensile strength [N/mm^2]

Table 5.1 C_1-values

z	1	2	4	6	≥8
C_1	1.0	1.1	1.2	1.3	1.4

Table 5.2 Values of C_w for shafts of nodular graphite cast iron

R_m	370	400	500	600	700	≥800
C_w	1.20	1.10	1.08	0.98	0.94	0.90

Table 5.3 Values of C_w for steel shafts

R_m	400	440	480	520	560	600	640	≥680	720(1)	≥760(1)
C_w	1.03	0.94	0.91	0.85	0.79	0.77	0.74	0.70	0.66	0.64

(1) For drop-forged crankshafts only.

5.2.2 Where higher strength is achieved by a favourable crankshaft geometry, lower values of dk may be allowed.

5.3 Screw compressors

The documents listed under 1.4.1 d) and e) are to be submitted.

5.4 Turbo compressors, special types

Where turbo compressors or special types are used as refrigerant compressors for refrigerating installations, detailed documentation is to be submitted for assessment.

Suitable evidence of the functional reliability is to be furnished to the Society prior to the first shipboard application of any type.

5.5 Material testing

Refrigerant compressors and compressor parts are to be subjected to material testing in accordance with 1.5.

5.6 Equipment

5.6.1 Provisions have to be made (e.g. in the form of overpressure safety switches) to ensure that the compressor drive switches off automatically should the maximum allowable working pressure be exceeded.

5.6.2 Compressors are to be equipped with devices such as pressure relief valves, rupture discs, etc., which, if the maximum allowable working pressure is exceeded, will equalize the pressures on the discharge and suction sides. Semi-hermetic compressors in automatic installations may be exempted from this Rule, provided that they are protected by overpressure safety switches and can be operated with permanently open shutoff valves in such a way that the safety valves fitted to the installation remain effective.

5.6.3 Air-cooled compressors are to be designed for an air temperature of at least 45 °C.

5.6.4 For seawater cooling, a minimum inlet temperature of 32 °C is to be applied. The cooling water spaces, unless provided with a free outlet, are to be protected against excessive overpressure by safety valves or rupture safety devices.

5.6.5 Pressure gauges and thermometers are to be fitted in accordance with 10.2.1 and 10.2.2.

5.6.6 A manufacturer's plate bearing the following information is to be permanently fixed to each refrigerant compressor:

manufacturer,

year of construction,

refrigerant and maximum allowable working pressure in bar.

5.7 Testing

After completion, refrigerant compressors are to be subjected to a trial run without refrigerant at the manufacturer's works and to the pressure and tightness tests specified in sub-section11.

6 Pressure Vessels and Apparatuses

6.1 Pressure vessels and apparatuses under refrigerant pressure

6.1.1 General

Pressure vessels and apparatuses under refrigerant pressure must comply with the requirements of Sec 5.

6.1.2 Material testing

The materials of components under refrigerant pressure must be tested in accordance with the Society's Rules for Materials.

6.1.3 Safety devices

6.1.3.1 Pressure vessels and apparatuses which contain liquid refrigerant and which can be shut off are to be fitted with a safety valve. For the design of safety valves see 10.1.

6.1.3.2 Filters and driers need not be fitted with safety valves provided that the refrigerant inlets and outlets cannot inadvertently be closed at the same time.

6.1.4 Pressure and tightness tests

After completion, pressure vessels and apparatuses under refrigerant pressure are to be subjected to the pressure and tightness tests specified in sub-section11.

6.2 Brine tanks

6.2.1 General

6.2.1.1 For the purposes of the present Rules, the term "brine" as a cooling medium means a solution of industrial salts. The use of other media with a low freezing point requires the approval of the Society.

6.2.1.2 In this context, brine tanks do not include brine cooling evaporators. The latter must comply with the requirements for pressure vessels and apparatuses under refrigerant pressure, as set out in 6.1.

6.2.1.3 Brine tanks may not be galvanized on the side in contact with the brine.

6.2.1.4 Brine systems must be equipped with air pipes which cannot be closed off and with brine compensating tanks.

6.2.1.5 Brine tanks which can be shut off must be protected against excessive pressure rises due to the thermal expansion of the brine by the provision of safety valves or by a mechanism for interlocking the shut off devices in the open position.

6.2.2 Testing

Brine tanks are to be subjected in the manufacturer's works to the hydraulic pressure and tightness tests specified in sub-section 11. Material tests and pneumatic tightness tests may in general be dispensed with.

6.3 Air coolers

6.3.1 General

6.3.1.1 Air coolers which work by direct evaporation count as apparatuses under refrigerant pressure and are therefore subject to the requirements in 6.1.

Notwithstanding this, safety devices are required only for flooded evaporators.

For the purpose of these Rules refrigerating installations with direct evaporation are those where the refrigerant evaporator is located in the refrigerated space itself or is connected to the latter, or to the containers, via air ducts. It follows that in such plant no brine or similar cooling medium is used.

6.3.1.2 Air coolers which work by indirect evaporation, in so far as brine is used as the cooling medium are subject to the application in analogous manner of the Rules set out in 6.2.1.3, 6.2.1.5 and 7.2.

6.3.1.3 Air coolers are to be designed for a maximum temperature difference between cooling medium and cooling air at the air cooler inlet of about 5 K for fruit cargo and about 10 K for deep-frozen cargo.

6.3.1.4 Where warranted by the temperature of the refrigerated space, air coolers are to be fitted with the means for defrosting. Defrosting by means of spraying with water is to be avoided. Provision is to be made for heating the drains. In automated plants, the heating equipment is to be controlled by the defrosting program.

6.3.1.5 Where finned-tube or multi-plate type air coolers are used, the distance between the fins or plates should not be less than 10 mm, at least on the air inlet side. In this context, the air inlet side is taken to mean 1/4 of the length of the cooler measured in the direction of air flow.

Where, in container refrigerating installations, an air cooler is provided for each container, a minimum distance of 6 mm between the fins or plates is permissible.

6.3.1.6 Depending on the type of air circulation system employed, the air coolers are to be subdivided by shut offs in such a way that, even after the breakdown of one air cooler section, the cooling of the refrigerated space or containers concerned can be maintained. The subdivision can be dispensed with where an air cooler is provided for each stack of containers or for each container.

6.3.1.7 Air coolers must be made of corrosion-resistant material or be protected against corrosion by galvanizing.

6.3.1.8 Air coolers are to be provided with drip trays and adequate drains.

6.3.2 Material testing

In accordance with 1.6. materials for air coolers using direct evaporation must be subjected to the tests specified in the Society's Rules for Materials.

In the case of air coolers for indirect evaporation, the testing of materials may be dispensed with if the cooling medium employed is brine.

6.3.3 Pressure and tightness tests

Air coolers are to be subjected to the pressure and tightness tests specified in sub-section 11, in the manufacturer's works. In the case of air coolers for indirect evaporation, the pneumatic tightness test may be dispensed with.

7 Pipes, Valves and Fittings

7.1 Refrigerant pipes

7.1.1 General

7.1.1.1 Refrigerant pipes are to be designed in accordance with the requirements of section 11.

7.1.1.2 When installing refrigerant pipes, care is to be taken to provide all pipes whose working temperatures are below the normal ambient temperatures with insulation in accordance with 12.1. These pipes are to be protected externally against corrosion. Unless some other form of corrosion protection has been demonstrated to the Society to be equally effective, steel pipes are to be galvanized on the outside.

7.1.1.3 At points where they are supported or pass through decks or bulkheads, the refrigerant pipes mentioned in 7.1.1.2 may not come directly into contact with steel members of the ship's structure.

7.1.1.4 Where necessary, refrigerant pipes between compressors and condensers are to be protected against being inadvertently touched.

7.1.2 Material testing

Materials for refrigerant pipes must be tested in accordance with the Society's Rules for Materials.

7.1.3 Tightness tests

After installation, all refrigerant pipes are to be subjected to the tightness test specified in sub-section 11.

7.2 Brine pipes

7.2.1 General

7.2.1.1 Brine pipes must comply with the rules requirements of section 11. They may not be galvanized on the inside, but must be protected externally against corrosion.

7.2.1.2 In general, use is to be made of thick-walled pipes with thickness corresponding to sea water pipes as stated in Sec 11, Table 2.2.

7.2.1.3 In the case of brine being used whose neutrality during subsequent operation is suitably ensured, the use of externally galvanized brine pipes with the minimum wall thicknesses specified in Section 11, may be permitted. This also applies to non-galvanized pipes which are uninsulated and which can be externally inspected and maintained at all times.

7.2.1.4 Where brine pipes pass through inaccessible spaces, their wall thicknesses are required to comply with Section 11, Table 2.2, with minimum reinforced wall thickness. The pipes and their insulation are to be installed in such a way that they are protected against damage.

7.2.1.5 At points where they are supported or pass through decks or bulkheads, brine pipes may not come directly into contact with steel members of the ship's structure.

7.2.2 Testing

After being installed but prior to the application of the insulation, brine pipes are to be subjected to the hydraulic pressure and tightness tests specified in 11.

Material tests and pneumatic tightness tests may generally be dispensed with.

7.3 Refrigerant valves and fittings

7.3.1 General

Refrigerant valves and fittings must comply with the requirements of section 11. Automatic control valves are to be arranged or fitted with by-passes so that the installation can also be operated by hand.

7.3.2 Testing

7.3.2.1 Refrigerant valves and fittings are subject to material testing if their housings are made of cast steel or nodular graphite cast iron and the product of the maximum allowable working pressure PB [bar] multiplied by the nominal diameter DN [mm] is > 2500.

Valves and fittings with DN ≤ 32 are exempted from this Rule.

7.3.2.2 Where the housings of valves and fittings are manufactured by drop forging or are made of copper alloys, material testing is not required.

7.3.3 Pressure and tightness tests

7.3.3.1 Refrigerant valves and fittings are to be subjected in the manufacturer's works to the pressure and tightness tests specified in sub-section 11.

7.3.3.2 Automatic control valves can be exempted from this requirement where the danger exists that sensitive internal components will be damaged by the pressure imposed in the pressure test. Where the design permits, the housings are to be tested without internal components in these cases.

7.4 Brine valves and fittings

7.4.1 General

Brine valves and fittings must comply with the requirements of section 11. The requirements specified in 7.2.1.1 also apply.

7.4.2 Testing

After being installed but prior to the application of the insulation, brine valves and fittings are to be subjected to the hydraulic pressure and tightness tests specified in sub-section 11.

Material tests and pneumatic tightness tests may generally be dispensed with.

8 Fans and Pumps

8.1 Fans

Motors driving the circulating fans of refrigerated holds must comply with the requirements of chapter 2. This also applies to motors driving the intake and exhaust fans of ships carrying fruit cargo.

After being installed the fans are to be tested in accordance with 16.1.5.

Provision must be made for replacing fan impellers and fan motors even when the refrigerated holds are fully loaded.

8.2 Refrigerant circulating pumps

8.2.1 At least two mutually independent pumps are to be installed, one of which is to act as a stand-by.

8.2.2 Evidence of the quality of the materials used is to be supplied in respect of all parts subject to refrigerant pressure.

8.2.3 Motors driving refrigerant circulating pumps must comply with the requirements of chapter 2.

8.2.4 Refrigerant circulating pumps are to be subjected in the manufacturer's works to a performance test and to the pressure and tightness tests specified in sub-section 11.

8.3 Brine pumps

8.3.1 At least two mutually independent pumps are to be installed, one of which is to act as a stand-by.

These pumps must be of well established design.

8.3.2 Motors driving brine pumps must comply with the requirements of chapter 2.

8.3.3 Brine pumps are to be subjected in the manufacturer's works to a performance test and to the hydraulic pressure and tightness tests specified in sub-section 11.

A pneumatic tightness test is not required.

8.4 Cooling water pumps

The requirements set out in 8.3. are applicable in analogous manner. Regarding the possible deletion of the stand-by pumps see 9.2.

9 Cooling Water Supply

9.1 General

Pipes, valves and fittings must comply with the requirements of section 11.

A suitable automatic cooling water control system is to be provided for the condenser pressure. Exceptions require the Society's approval.

9.2 Reserve cooling water supply

Where the reserve cooling water supply system of the refrigerating installation is connected to the cooling water system of the main propulsion plant, the standby cooling water pump specified in 8.4. may be dispensed with provided that the stand-by cooling water pump of the main propulsion plant is capable of the adequate supply of cooling water to the refrigerating installation without adversely affecting the operation of the main propulsion plant.

9.3 Suction lines

Each cooling water pump must be equipped with its own suction line and must be able to draw from at least two sea chests. Seawater filters are to be fitted and so arranged that they can be cleaned without interrupting the cooling water supply.

9.4 Dock operation

By suitable connection of the cooling water lines to ballast water tanks or by hose connections to the deck washing line or fire main, steps shall be taken to ensure that, when necessary, the refrigerating installation can also be operated while the ship is docked.

9.5 Cooling water pipes in cargo holds

Where cooling water pipes have to be laid through cargo holds or refrigerated cargo holds to the refrigerating machinery spaces, they are to be installed in pipe tunnels. In exceptional cases cooling water pipes may be installed above deck or in the double bottom tank.

Where cooling water pipes pass through double bottom tanks, their wall thickness is required to comply with the requirements of section 11.

9.6 Testing

After being installed, cooling water pipes, valves and fittings are to be subjected to the pressure and tightness tests specified in sub-section 11.

10 Safety and Monitoring Equipment

10.1 Safety equipment

10.1.1 General

10.1.1.1 Provisions are to be made to ensure that if the maximum allowable working pressure according to 3.2. is exceeded, the compressor drive switches off automatically.

10.1.1.2 Pressure vessels and apparatuses which can be isolated and which contain liquefied refrigerants must be equipped with a safety valve; see also 6.1.3.

10.1.1.3 Provision must be made for the safe blow-off of refrigerants directly into the open air.

10.1.2 Safety valves and rupture discs

10.1.2.1 Safety valves exposed to refrigerant pressure are subject to the requirements set out in 7.3. The provisions of 7.4 are applicable in analogous manner to safety valves under brine pressure.

10.1.2.2 Safety valves are to be set to the maximum allowable working pressure and secured to prevent the setting from being altered inadvertently.

10.1.2.3 Fitting a rupture disc in front of a safety valve is permitted only where, between the rupture disc and the safety valve, no uncontrolled pressure build-up can occur which, in the event of a sudden pressure surge, would not allow either the safety valve or the rupture disc to respond.

The space between the rupture disc and the safety valve cone must therefore be fitted with an alarm pressure gauge or equivalent device. Instead of this a free outlet duct may also be used, provided that it traverses oil-filled sight glasses or the like which reveal any leakage through the rupture disc.

A screen for the retention of broken fragments is to be fitted behind the rupture disc.

10.1.2.4 Where rupture discs are used, the Society requires evidence that the bursting pressure does not exceed the maximum allowable working pressure. A 10 % margin of tolerance is permitted.

10.2 Monitoring equipment

10.2.1 Pressure gauges

The suction and pressure pipes of refrigerant compressors, intermediate stage pressure vessels and pressurized brine pipes are to be fitted with pressure gauges. Refrigerant pressure gauges are required to have pressure and temperature scales for the refrigerant concerned. The maximum allowable working pressure is to be indicated by a red line.

10.2.2 Thermometers

Brine delivery and return pipes, condenser cooling water inlet and outlet pipes and pressure and suction pipes of compressors are to be fitted with thermometers.

For the number and disposition of thermometers in refrigerated cargo holds and in the air duct systems of refrigerated containers, see 14.

10.2.3 Liquid level indicators

Direct indicators such as sight glasses for liquid refrigerants used in plants operated with ammonia are to be so designed that they can be shutoff.

The use of tubular glasses is not permitted.

11 Pressure and Tightness Tests

11.1 General

11.1.1 All pressure tests are to be performed in the presence of a Surveyor. They are to be carried out initially during supervision of construction at the manufacturer's works or, in the case of a survey for the assignment of class, on board ship.

11.1.2 As a rule, pneumatic tightness tests are to be performed after the hydraulic pressure tests.

11.1.3 Exceptionally, the Society may, on application, waive the hydraulic pressure test provided that a pneumatic pressure test is performed at the test pressure specified for the hydraulic test.

11.1.4 In refrigerating installations which have already been charged with refrigerant, pneumatic pressure tests may be performed only with nitrogen or carbon dioxide if Group 1 refrigerants are used or only with nitrogen if the refrigerant is ammonia.

The use of other gases requires the agreement of the Society.

11.1.5 The refrigerating system is to be dried before the plant is filled with refrigerant.

11.2 Test pressures

11.2.1 Components under refrigerant pressure

The test pressures to be used are specified in Table 11.1. According to the refrigerant used, HP is to be substituted by the design pressure on the highpressure side and LP by the design pressure on the low-pressure side in accordance with Table 3.1.

11.2.2 Components under cooling water or brine pressure

The test pressures shown in Table 11.2 are to be applied.

Table 11.1 Test pressures for components under refrigerant pressure

Test	Item to be tested	Test pressure [bar] [1]	
		hydraulic	pneumatic
Prior to installation	Compressor (high-pressure side)	1.5 HP	HP
	Compressor (low-pressure side)	1.5 LP	LP
	Compressors with integrally cast cylinders and crankcase	1.5 HP	HP
	Motor compressors, assembled	-	HP
	Refrigerant circulating pumps	1.5 HP	HP
	High-pressure vessels and apparatuses	1.5 HP	HP
	Low-pressure vessels and apparatuses	1.5 LP	LP
	Refrigerant valves and fittings (except automatic control valves)	1.5 HP	HP
Prior to start-up	Complete installations:		
	High-pressure side	-	HP
	Low-pressure side	-	LP

1) Where the low-pressure side of the installation can be subjected by operational switching to the pressure of the high-pressure side (e.g. for defrosting with hot gas), the vessels and equipment involved are to be designed and tested at the pressures prescribed for the high-pressure side.

Table 11.2 Test pressure for components under cooling water or brine pressure

Test	Item to be tested	Hydraulic test pressure [1]
Prior to installation	Cooling water spaces of machines and equipment, cooling water pumps	1,5 $p_{e,zul}$, minimum 4 bar
	Vessels and equipment on the pressure side of brine pumps, brine pumps	1,5 $p_{e,zul}$, minimum 4 bar
	Vessels and equipment on the suction side of brine pumps	1,5 $p_{e,zul}$, minimum $p_{e,zul}$ + 0,2 bar
Prior to start-up	Cooling water lines, valves and fittings	1,5 $p_{e,zul}$, minimum 4 bar
	Brine pipelines, valves and fittings (prior to insulation)	1,5 $p_{e,zul}$, minimum 4 bar

1) $p_{e,zul}$ [bar] = maximum allowable working pressure in the part concerned.

12 Insulation of Pressure Vessels, Apparatus, Pipes, Valves and Fittings

12.1 Cold insulation

12.1.1 All pressure vessels, apparatuses, pipes, valves and fittings whose operating temperatures may drop below the ambient temperature at the points where they are installed are to be provided with cold insulation. Items of plant which are accommodated in specially insulated refrigerating machinery spaces are exempted from this requirement.

12.1.2 Refrigerant and brine pipes which traverse uncooled spaces are to be insulated with special care and are to be installed so that they are protected from damage.

12.1.3 Assuming that the refrigerating installation has sufficient reserve capacity, cold insulation need not be fitted at control stations and control groups nor to apparatus, pipes, valves and fittings in refrigerated or air cooler spaces which are intended to serve exclusively for the refrigeration of the said spaces, provided that no damage can be caused there by dripping condensation water.

12.1.4 All air, sounding, thermometer and drain pipes in refrigerated and air-cooler spaces are to be adequately insulated.

12.1.5 Before being insulated, the items concerned are to be protected against corrosion.

12.1.6 Cold insulation is to be at least sufficiently thick to prevent the formation of condensation water on its surface at a maximum relative humidity of 90 %.

12.1.7 The insulation is to be free from discontinuities and its final layer must be given a vapourtight coating.

12.1.8 Insulation is to be protected at points where there is a danger of damage.

12.2 Heat insulation

12.2.1 For insulation used to prevent accidental touching and fitted to pressure pipes between refrigerant compressor and condenser and to oil separators on the pressure side, see 7.1.1.4.

12.2.2 To avoid premature refrigerant condensation, hot gas defrosting pipes are to be insulated over their entire length.

12.2.3 Components requiring insulation are to be protected against corrosion.

13 Equipment and Insulation of Refrigerated Spaces and Air Ducts

13.1 Equipment

13.1.1 The external boundary walls of refrigerated spaces are to be watertight and made of steel. If the use of other materials is envisaged, the agreement of the Society is required.

Separately refrigerated spaces or groups of spaces are to be made airtight to prevent the taste, odour or ripening process from being adversely affected. All openings in the boundary walls of refrigerated holds are to be provided with airtight covers.

13.1.1.1 Air duct systems with built-in air coolers and circulating fans as well as couplings for attaching insulated containers must be airtight.

13.1.2 Manholes in the double bottom or in oil tank tops are to be surrounded with an oiltight coaming 100 mm in height.

13.1.3 Brine or refrigerant pipe penetrations through watertight bulkheads and decks must be of approved design. The pipes may not come into direct contact with bulkheads, ship's structure or other metal structural members. The fire resistance of the bulkheads and decks may not be impaired.

13.1.4 The clear openings of access trunkways and companion hatches leading to cargo or air cooler spaces may not measure less than 600 mm by 600 mm. Hinged hatch covers are to be protected against closing accidentally and must be capable of being re-opened by hand from inside.

13.1.5 Access doors or hinged hatch covers from companionways leading to cold rooms which are used for operational purposes, such as refrigerated spaces or air cooler spaces, refrigerated provision stores and also brine spaces must be capable of being opened from inside, irrespective of their closed condition.

These spaces are to be fitted with an alarm which must be connected to a station which is constantly monitored.

13.1.6 The supports of inspection gangways and refrigerated spaces are to be designed with sufficient strength to absorb the load exerted by the cargo.

13.1.7 Air ducts of refrigerated holds are to be fitted with fire flaps. Where the cargo makes this necessary, each refrigerated hold is to be provided with separately installed air intake and exhaust ducts.

13.1.8 Refrigerated spaces are to be provided with drains and/or bilge pumping facilities. In this connection, see the requirements in section 11.

13.1.9 Circulating fans and air coolers installed in refrigerated or air cooler spaces must be accessible at all times. It must be possible to change fan impellers and drive motors even when the cargo spaces are fully loaded (see also 8.1.)

13.1.10 Provision is to be made for heating the spaces should this be made necessary by the cargo or the route travelled.

13.2 Insulation

13.2.1 The inside surfaces of refrigerated spaces are to be adequately insulated. Thermal bridges are to be avoided. Structural members of the ship which may act as thermal bridges, e.g. decks, partitions and pillars, are to be fully insulated over a length of at least 1 m into the refrigerated space.

13.2.2 Divisions, bulkheads and decks separating refrigerated spaces at the same temperature need not be insulated. However, the requirement in 13.2.1 is to be complied with. Cladding is to be fitted to protect the cargo.

13.2.3 Insulating materials must be odourless and must not, as far as possible, absorb any moisture.

Insulating materials, along with their cladding, must have highly flame-resistant properties to recognized standards. Polyurethane foams and insulating materials which have comparable flame-resistant properties may only be used with a metal or equivalent cladding.

The insulating materials used in refrigerated spaces must be approved by ACS. Where in-situ cellular plastic is used, the respective processing methods and also the processing recommendations issued by the manufacturer are to be submitted for examination. The behaviour of insulating material in fire is to be proven, on demand, by means of independent tests.

13.2.4 If timber is used in refrigerated cargo spaces, this is to be impregnated with, if possible odourless, media to prevent rotting and fire.

13.2.5 Insulation is to be permanently secured.

Where insulation in the form of slabs is used, the edges of the slabs are to abut tightly against each other and where the slabs are laid in several layers the joints are to be staggered.

13.2.6 The insulation at manhole covers, bilge suctions and wells must be removable.

13.2.7 Refrigerated spaces should not lie adjacent to fuel or lubricating oil tanks. Where this cannot be avoided, a sufficiently wide gap is to be left between the vertical surfaces of such tanks and the insulation.

This gap is to be provided with a drain leading to the bilge and with a vent pipe leading to the open air. The back of the insulation is to be protected against the penetration of moisture, e.g. by metal cladding.

13.2.8 The requirements set out in the previous paragraph apply in analogous manner to the tops of lubricating oil and fuel tanks. In the case of welded tank tops, the specified isolating gap may be dispensed with, provided that the top is covered with a well established oilproof coating without joints and of sufficient thickness.

13.2.9 For the insulation of piping in refrigerated spaces, see 12.

13.2.10 The edges of insulated hatches and hatch covers, doors, bilge covers etc. are to be protected against damage.

13.2.11 At hatches, and for about 500 mm beyond, the deck insulation in lower holds is to be provided with a special protective covering. The same also applies to shaft tunnels.

13.2.12 Unless suitable deck material or aluminium gratings are provided as top covering, the insulation of the decks of refrigerated spaces is to be protected by battens measuring at least 50 mm by 50 mm in cross section.

The battens may take the form of removable gratings. Thinner battens may be used in refrigerated spaces in which the cargo carried is invariably suspended.

13.2.13 The insulation of the bulkheads of refrigerated spaces and of air ducts is to be suitably protected against damage. This protection is to be so designed that the air circulation is not affected.

13.2.14 Wherever applicable, the requirements set out in 13.2 apply analogously to air ducting systems for the connection of insulated containers.

13.3 Testing

13.3.1 The equipment and insulation of refrigerated spaces is to be tested under the supervision of the Society. Compliance with the prescribed heat transfer values is to be demonstrated by performing the refrigeration test specified in 16.2.

13.3.2 In order to simplify shipboard trials, air ducting systems with integral couplings and with built-in air coolers and air circulating fans which are completely fabricated at the works and which serve one container or one stack of containers are to be subjected to the following tests in the manufacturer's works under the supervision of the Society:

13.3.2.1 Measurement of the heat transfer rate of each type by means of a heating test with a period of at least six hours in the steady state. The test procedure is to be agreed on with the Society.

13.3.2.2 Measurement of the air leakage rate of each ducting system using an internal overpressure of 250 Pa above atmospheric.

13.3.2.3 Measurement of the air distribution in each ducting system (for every container air delivery connection).

13.3.2.4 Measurement of the power consumption of the air circulating fan for each ducting system.

13.3.2.5 Measurement of the air renewal rate for each ducting system.

14 Temperature Monitoring Equipment for Refrigerated Spaces and Refrigerated Containers

14.1 General

14.1.1 Suitably distributed and easily accessible thermometers are to be placed in each refrigerated space. At least one thermometer each is required before and after each air cooler.

14.1.2 Based on spaces of normal geometry and on the useful capacities shown, the following numbers of thermometers are to be fitted as a minimum:

for space capacities up to approximately	300 m^3 = 2 thermometers
for space capacities up to approximately	800 m^3 = 3 thermometers
for space capacities over	800 m^3 = 4 thermometers

In determining the number of thermometers required, each individual refrigerated space is to be considered separately, even where several spaces are served by a single air cooler and the twin decks are not insulated.

14.1.3 In container refrigerating installations, each container is to be fitted with one thermometer each at the inlet and return connections for the air ducting system. Where cooling is applied by a common supply duct to one stack of containers, the individual thermometers for the supply air may be replaced by one thermometer to each stack, placed in the supply duct close to the air cooler.

14.1.4 Calibrated thermometers are to be used which give a reading of the accuracy required by the cargo.

14.1.5 Where thermometer tubes are fitted, these are required to have an inside diameter of at least 50 mm.

If the thermometer tubes are to be operated from the free deck, screw connections and tubes are to be insulated from the deck plating. Where they pass through other spaces, the tubes are to be effectively insulated. They are to be so arranged that water cannot enter them.

14.2 Electrical temperature monitoring equipment

14.2.1 Where temperatures are not monitored locally, electrical devices are to be fitted which comply both with the following requirements and the Rules of chapter 2.

14.2.2 In design and type of enclosure, all appliances and other system components must be compatible with the mechanical and climatic conditions attaching to their particular operating environments. So that they can be used in refrigerated cargo, mobile temperature sensors may be used in refrigerated holds. They are then to be fitted with connecting leads of sufficient length. The sensors are to be protected against mechanical damage.

14.2.3 At least two mutually independent temperature measuring systems with separate power supply are to be provided. The measuring points of each refrigerated space are to be evenly distributed on these temperature measuring systems.

Other systems may be approved provided that a representative temperature measurement can be ensured for each independently refrigerated space in the event of failure of any of the components inside the measuring chain. If this can only be ensured by replacing individual modules these are to be carried on board as spares. It must be possible to replace spare parts of this nature within a reasonable timescale and without any onboard programming being required. The failure of every component is to be signaled by an alarm.

14.2.4 The number of measuring points (sensors) in refrigerated spaces depends on the location and size of each space.

The requirements set out in 14.1.1 and 14.1.2 or 14.1.3 are to be complied with as a minimum.

14.2.5 In air ducting systems for container refrigeration, the measuring points in the delivery and return air ducts are to be coupled to separate indicating instruments, unless provision is made for local measurement of at least the delivery air temperatures.

14.2.6 The measuring range of the systems must cover the entire anticipated temperature range plus an additional ±5 K. Temperatures above or below the measuring range shall not have any harmful effect on the systems.

14.2.7 The accuracy of the temperature measurement and reading must be compatible with the requirements imposed by the sensitivity of the cargo with regard to temperature fluctuations. In the absence of special requirements, the following values are to be applied:

Maximum total error

for fruit cargo	0.15 K (in range from + 10 °C to + 15 °C)
for deep-frozen cargo	0.5 K.

Exceptions are subject to the Society's special approval.

For analog readings, the scale calibration must be at least 10 mm/K for fruit cargo and at least 2.5 mm/K for deep-frozen cargo.

The temperature measurement may not be influenced by the duration of the duty cycle of the sensor.

Changes in the resistance of the measuring leads due to temperature fluctuations between 0 °C and + 40 °C along the wire and/or fluctuations of ± 20 % in the measuring voltage may not cause the aforementioned total errors to be exceeded.

14.2.8 Measuring instruments and their illumination are to be so arranged that they can be reliably read without difficulty.

14.2.9 Wires and their installations must comply with the Construction Rules for Electrical Plant. Waterproof distribution and junction boxes must be used.

14.2.10 Each temperature measuring system must be provided with its own power supply. The power supply systems are to be electrically independent of each other and of the shipboard supply system.

14.2.11 Where temperature measuring systems are supplied by their own power sources or via converters from the ship's network, provision must be made for simple switching to a stand-by power source or to a stand-by converter, e.g.: Where power is drawn from storage batteries, at least two batteries must be provided for each measuring system. These must be so connected that they can be switched alternately to charge and discharge.

Where power is drawn from primary cells (dry cell batteries) or rechargeable batteries, these must be easily changeable.

Where power is supplied from the ship's network via a converter, means must be provided for switching over the mains-connected appliances to a stand-by converter.

The mains unit of a temperature measuring system is not subject to these requirements (cf. 15.1. Spare parts).

14.2.12 Instruments and appliances must be marked with their type and number.

14.2.13 The system and its individual components are to be subjected to a test in the manufacturer's works under the supervision of the Society. The Society may recognize this as a type-test for other installations of the same design.

The following shipboard tests are to be performed in each case:

Checking the system and the spare parts against the approved drawings and descriptions; operational test; inspection of the electrical installation.

15 Spare Parts and Protective Equipment

15.1 Spare parts

15.1.1 To enable the operation of the refrigerating plant to be restored in the event of damage at sea, at least the spare parts listed in Table 15.1 are to be carried on board every ship.

Table 15.1 Spare parts

1	Compressor piston with piston rod and crank bearing of each type, ready for fitting
1	Set of piston rings of each type for 1 piston
1	Set of suction and delivery valves of each type for 1 cylinder
1	Shaft seal of each type ready for fitting
10%	of all expansion valves (including at least one of each type) for the refrigerant circuit
1	Suction and delivery valve stem of each type, with cone and seat, for the main shutoff valves of the compressors
1	of each type of pressure switch for suction and pressure lines
1	Pressure gauge of each type
10%	of all thermometers for the refrigerating machinery and the refrigerated spaces, including at least two of each type
1	Set of V-belts of each length, for 1 compressor
1	Oil sight glass of each type with gaskets
1	Fan impeller of each type
2%	of pipe plugs for steel condenser tubes
1	Complete set of all rupture discs Packing jointing and sealing materials, a few lengths of the most widely used types of pipe, screw couplings, flanges nuts and bolts and device for topping up refrigerant charge
1	Detector for tracing leaks in the refrigerant system
10%	of all sensors for electrical remotely operated thermometers, including at least 1 of each type
1	Galvanometer for every five indicating instruments, including at least one of each type
1	Mains unit, including rectifier and transformer, where power is supplied from the ship's network; the electrolytes necessary for the operation of the batteries together with filling devices and meters, where power is drawn from batteries
1	Battery for battery power supply
1	for every module described in 14.2.3

15.1.2 Depending on the design and arrangement of the cargo refrigerating plant and the manufacturer's recommendations, a different range of spare parts may exceptionally be agreed between the shipowner and the Society.

Where the stock of spare parts is based on special arrangements between the shipowner and the Society, technical documentation is to be provided. A list of the spare parts is to be carried on the ship.

15.1.3 Spare parts for the electrical machines driving compressors, pumps and refrigerating space circulating fans are governed by the Rules for Construction of Electrical Plant.

15.2 Protective equipment

The provision of gas masks, respirators, protective clothing etc. is subject to the accident prevention regulations in force.

16 Shipboard Testing

16.1 Operational tests

The refrigerating installation is to be subjected to the following tests:

16.1.1 All compressors, pumps, fans, etc. are to be run simultaneously and demonstrated to the Society's Surveyor in all the anticipated speed ranges. It is to be proved that no unacceptable vibrations occur.

16.1.2 To test their functional efficiency, all compressors are to be operated both individually and together at various speeds of rotation and at different evaporation temperatures. During the test they are to be connected to the condensers and evaporators in all the combinations possible in service.

16.1.3 The condensers are to be operated first with the normal cooling water pump and then with the stand-by cooling water pump. Operation of the cooling water supply when in dock, in accordance with 9.4, is to be demonstrated.

16.1.4 Brine pumps are to be tested.

16.1.5 Circulating fans are to be operated at their specified service speeds - or with the prescribed blade settings in the case of variable-pitch fans - and the delivery rates measured. It is to be demonstrated to the Society that the requisite rate of air renewal and uniform space ventilation are achieved.

16.1.6 The working of the defrosting devices for the air coolers is to be demonstrated.

16.1.7 The temperature variations of the cargo room sensors are to be determined and recorded (e.g. ice water test).

16.2 Refrigeration test for cargo refrigerating installations

16.2.1 A refrigeration test is to be performed to demonstrate to the Society that the degree of thermal insulation of the refrigerated spaces and the available refrigerating capacity of the refrigerating installation comply with the requirement set out in 2.3 to 2.6.

The refrigeration test is to be performed by means of a heat balance test. The proof of performance is deemed to have been supplied if the heat transfer coefficient used as a basis in the calculation of the refrigeration demand is confirmed by the Society's analysis of the test results, taking into account the capacity of the refrigerating plant.

16.2.1.1 Where, in exceptional cases, only the thermal insulating effect of the refrigerated space insulation is to be tested, a twin radiation test (twin test) may be accepted as the method of testing.

The test procedure is to be agreed with the Society.

16.2.2 The temperature in the refrigerated holds is to be lowered to the level corresponding to the refrigerated space temperature specified for the installation.

For this purpose, the temperature difference between the ambient air and the refrigerated spaces should not, if possible, be less than 15 K.

16.2.3 In order to achieve thorough, uniform cooling of all parts, the refrigerated hold temperature is to be held constant at the later balance temperature for a period of at least ten hours. At the end of the cooling period, the refrigerating machinery must be in a steady operating condition.

16.2.4 The temperature measurements for the balance test are to be performed over a period of at least six hours during a time when the outside temperature is as constant as possible. Periods of strong solar radiation are to be avoided.

16.2.5 While measurements are being made, all machinery and equipment in use is to be maintained in a steady operating condition. During this time, no additional fresh air may be supplied to the refrigerated holds.

16.2.6 However, in order to establish the performance of the refrigerant compressors with sufficient accuracy, the balance test is to be carried out during the actual balance time using manual control.

16.2.7 The number of compressors needed to achieve the condition of balance is to be fixed so as to achieve continuous operation. If, under the test conditions, the capacity of even a single compressor is too great, the plant must be operated intermittently while recording the "on" time. The switching off of individual cylinders or rows of cylinders is not allowed.

16.2.8 The following measurements are to be carried out:

a) Refrigerated spaces: the temperatures in the refrigerated spaces and at the air coolers. In addition, the temperature curve is to be plotted by means of a temperature recorder. However, the test temperatures may not be read from the recorded graph.

b) Ambient condition and other ship's spaces: the temperatures of the ambient air and of the water are to be measured as are also the temperatures of other ship's spaces adjoining the refrigerated holds.

c) Compressors: pressure and temperature of the refrigerant on the suction and pressure sides, rotating speed of the compressors, and the power consumption of the drive motors. In the case of semi-hermetic motor compressors, measurement of the speed of rotation may be dispensed with.

d) Condenser: outlet temperatures of the refrigerant.

e) Brine: the temperature of the brine before and after the brine coolers, the pressure at the brine pump outlets, and the power consumption of the brine pumps.

f) Circulating fans for the refrigerated spaces: the power consumption of the fan motors. During the balance time, recordings are to be made hourly, otherwise every two hours. Care is to be taken to measure the ambient temperatures outside the refrigerated holds needed for the evaluation every hour over a period of 4 to 6 hours prior to the balancing time, depending on the insulation.

16.2.9 After the balance test, the following documents are to be submitted to the Society's Head Office:

a) A diagrammatic drawing of the ship and the refrigerated holds showing the points of temperature measurement.

b) A report on the test schedule including all the measured data and photocopies of the recorded temperature charts.

c) The ship's draught, fore and aft.

16.3 Refrigeration test for container refrigerating installations

16.3.1 The Society may accept as an adequate shipboard trial an operational test analogous to that described in 16.1., subject to sufficient steady-state times for adjustments, provided that the following conditions are satisfied:

16.3.1.1 For the supply of cooling air to the containers exclusive use is made of air ducting systems in accordance with 13.1.1.1 which have been satisfactorily tested in the manufacturer's works, as prescribed in 13.3.2.

16.3.1.2 The manufacturer demonstrates by calculation the ample capacity of the refrigeration plant and the values applied in this calculation conform to ACS's experience with comparable systems.

16.3.1.3 An adequate number of containers is made available for the operational test.

16.3.2 If one of the conditions specified in 3.1 is not fulfilled, the refrigeration test is to be performed, in a manner analogous to that described in 16.2, once for at least one empty container hold and once with a sufficient number of containers connected.

16.3.3 The documents specified in 16.2.9 b) and c) are to be submitted.

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 respect of the criteria imposed by the Rules. The tests are to be witnessed by a Surveyor.

1.3 Documentation to be submitted

1.3.1 A comprehensive list of the shipboard tests intended to be carried out by the shipyard is to be submitted to the Society.

For each test, the following information is to be provided:

- scope of the test
- parameters to be recorded.

2 General requirements for 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) protection of the various installations, as regards:

- the protection of mechanical parts
- the safeguards for personnel

d) accessibility for cleaning, inspection and maintenance.

Where the above features are not deemed satisfactory and require repairs or alterations, the Society reserves the right to require the repetition of the trials at the moorings, either wholly or in part, after such repairs or alterations have been carried out.

2.2 Sea trials

2.2.1 Scope of the tests

Sea trials are to be conducted after the trials at the moorings and are to include the following:

a) demonstration of the proper operation of the main and auxiliary machinery, including monitoring, alarm and safety systems, under realistic service conditions

b) check of the propulsion capability when one of the essential auxiliaries becomes inoperative

c) detection of dangerous vibrations by taking the necessary readings when required.

3 Shipboard tests for machinery

3.1 Conditions of sea trials

3.1.1 Displacement of the ship

Except in cases of practical impossibility, or in other cases to be considered individually, the sea trials are to be carried out at a displacement as close as possible to the deadweight (full load) or to one half of the deadweight (half load).

3.1.2 Power of the machinery

a) The power developed by the propulsion machinery in the course of the sea trials is to be as close as possible to the power for which classification has been requested.

In general, this power is not to exceed the maximum continuous power at which the weakest component of the propulsion system can be operated. In cases of diesel engines and gas turbines, it is not to exceed the maximum continuous power for which the engine type concerned has been approved.

b) Where the rotational speed of the shafting is different from the design value, thereby increasing the stresses in excess of the maximum allowable limits, the power developed in the trials is to be suitably modified so as to confine the stresses within the design limits.

3.1.3 Determination of the power and rotational speed

a) The rotational speed of the shafting is to be recorded in the course of the sea trials, preferably by means of a continuous counter.

b) In general, the power is to be determined by means of torsiometric readings, to be effected with procedures and instruments deemed suitable by the Society.

As an alternative, for reciprocating internal combustion engines and gas turbines, the power may be determined by measuring the fuel consumption and on the basis of the other operating characteristics, in comparison with the results of bench tests of the prototype engine.

Other methods of determining the power may be considered by the Society on a case by case basis.

3.2 Starting from dead ship conditions

3.2.1 The capability of the machinery installations to be brought into operation from a dead ship condition without external aid is to be demonstrated.

3.2.2 The capability of the propulsion to be restored from dead ship conditions within 30 minutes is to be demonstrated.

3.3 Navigation and maneuvering tests

3.3.1 Speed trials

a) Where required by the Rules, the speed of the ship is to be determined using procedures deemed suitable by the Society.

b) The ship speed is to be determined as the average of the speeds taken in not less than two pairs of runs in opposite directions.

3.3.2 Astern trials

a) The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, and so to bring

the ship to rest within reasonable distance from maximum ahead service speed, shall be demonstrated and recorded.

b) The stopping times, ship headings and distances recorded on trials, together with the results of trials to determine the ability of ships having multiple propellers to navigate and manoeuvre with one or more propellers inoperative, shall be available on board for the use of the Master or designated personnel.

c) Where the ship is provided with supplementary means for maneuvering or stopping, the effectiveness of such means shall be demonstrated and recorded as referred to in paragraphs a) and b). For electric propulsion systems, see 3.9.

3.4 Tests of boilers

3.4.1 General

The satisfactory operation of the main and auxiliary boilers supplying essential services is to be ascertained in all operating conditions during the trials at the moorings and the sea trials.

3.4.2 Tests to be performed

After installation on board, the following tests are to be carried out in the presence of the Surveyor:

a) Test in the hot condition of boilers and superheaters

b) Accumulation tests and setting of safety valves of boilers and superheaters

- Safety valves are to be set to lift at a pressure not exceeding 103% of the design pressure
- For boilers fitted with superheaters, the safety valves of the latter are to be set to lift before or, at the latest, at the same time as the valves of the saturated steam chest

c) Verification that, at the maximum steaming rate, the boiler pressure does not exceed 110% of the design pressure when the stop valves of the boiler, except those which must remain open for the burning operation, are closed. The boiler is to be fed so that the water level remains normal throughout the test. The test is to last:

- 15 minutes for fire tube boilers
- 7 minutes for water tube boilers.

d) Test and simulation of all safety devices, alarms, shut-off and automatic starting of standby equipment.

3.4.3 Alternative requirement

a) When it is recognized, for certain types of boilers, that accumulation tests might endanger the superheaters, the omission of such tests may be considered.

b) Such omission can be permitted, however, only if the drawings and the size of safety valves have been reviewed by the Society, and provided that the safety valves are of a type whose relieving capacity has been established by a test carried out in the presence of the Surveyor, or in other conditions deemed equivalent to those of the actual boiler.

c) When the Society does not agree to proceed with an accumulation test, the valve manufacturer is to supply, for each safety valve, a certificate specifying its relieving capacity for the working conditions of the boiler. In addition, the boiler manufacturer is to supply a certificate specifying the maximum steam capacity of the boiler.

3.5 Tests of diesel engines

3.5.1 General

a) The scope of the trials of diesel engines may be expanded in consideration of the special operating conditions, such as towing, trawling, etc.

b) Where the machinery installation is designed for residual or other special fuels, the ability of engines to burn such fuels is to be demonstrated.

3.5.2 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 n0 for at least 4 hours

b) operation at engine speed corresponding to normal continuous cruise power for at least 2 hours

c) operation at engine speed n = 1.032 n0 for 30 minutes

Note 1: The present test is to be performed only where permitted by the engine adjustment.

d) operation at minimum load speed

e) starting and reversing manoeuvres

f) operation in reverse direction of propeller rotation at a minimum engine speed of n = 0.7 n0 for 10 minutes

Note 2: The present test may be performed during the dock or sea trials.

g) tests of the monitoring, alarm and safety systems

3.5.3 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 3.5.2.

b) Engines driving controllable pitch propellers are to be tested at various propeller pitches.

3.5.4 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 4 hours

b) operation at normal continuous cruise power for at least 2 hours

c) operation at 110% power for 30 minutes

d) operation in reverse direction of propeller rotation at a minimum engine speed 70% of the nominal propeller speed for 10 minutes

Note 1: The present test may be performed during the dock or sea trials.

e) starting manoeuvres

f) tests of the monitoring, alarm and safety systems.

Note 2: The above six tests are to be performed at rated speed with a constant governor setting. The powers refer to the rated electrical powers of the driven generators.

3.5.5 Engines driving auxiliaries

a) Engines driving generators or important auxiliaries are to be subjected to an operational test for at least 4 hours. During the test, the set concerned is required to operate at its rated power for at least 2 hours.

b) 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 times needed to actuate the generator's overload protection system.

3.6 Test of air starting system for main and auxiliary engines

3.6.1 The capability of the starting air system to charge the air receivers within one hour from atmospheric pressure to a pressure sufficient to ensure the number of starts required in Sec 11, 17.3.1 for main and auxiliaries engines is to demonstrated.

3.7 Tests of steam turbines

3.7.1 Main propulsion turbines

Main turbines are to be subjected during dock trials and subsequent sea trials to the following tests:

- operation at rated rpm for at least 3 hours
- reversing manoeuvres
- astern revolutions equal to at least 70% of the rated ahead rpm for approximately 30 minutes.

During astern and subsequent forward operation, the steam pressures and temperatures and the 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.

3.7.2 Auxiliary turbines

Turbines driving electric generators or auxiliary machines are to be run for at least 4 hours at their rated power and for 30 minutes at 110% of rated power.

During the trials all safety, alarm, shut-off and control systems associated to the turbine are to be tested or properly simulated.

3.8 Tests of gas turbines

3.8.1 Main propulsion turbines

Main turbines are to be subjected during dock trials and subsequent sea trials to the following tests:

- operation at rated rpm for at least 3 hours
- ship 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.

3.8.2 Auxiliary turbines

Turbines driving electric generators or auxiliary machines are to be run for at least 4 hours at their rated power and for 30 minutes at 110% of rated power.

During the trials all safety, alarm, shut-off and control systems associated to the turbine are to be tested or properly simulated.

3.9 Tests of electric propulsion system

3.9.1 Dock trials

a) The dock trials are to include the test of the electrical production system, the power management and the load limitation.

b) A test of the propulsion plant at a reduced power, in accordance with dock trial facilities, is to be carried out.

During this test, the following are to be checked:

- electric motor rotation speed variation
- functional test, as far as practicable (power limitation is to be tested with a reduced value)
- protection devices
- monitoring and alarm transmission including interlocking system.

c) Prior to the sea trials, an insulation test of the electric propulsion plant is to be carried out.

3.9.2 Sea Trials

Testing of the performance of the electric propulsion system is to be effected in accordance with an approved test program.

This test program is to include at least:

- Speed rate of rise
- Endurance test:
  - operation at normal continuous cruise power for at least 4 hours
  - 1 hour at 100% rated output power with winding temperature rise below 2°K per hour, according to IEC publication 60034-1
  - operation in reverse direction of propeller rotation at the maximum torque or thrust allowed by the propulsion system for 10 minutes.
- 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 ship turning test
- Test of power management performance: reduction of power due to loss of one or several generators to check, in each case, the power limitation and propulsion availability.

3.10 Tests of gears

3.10.1 Tests during sea trials

During the sea trials, the performance of reverse and/or reduction gearing is to be verified, both when running ahead and astern.

In addition, the following checks are to be carried out:

- check of the bearing and oil temperature
- detection of possible gear hammering, where required
- test of the monitoring, alarm and safety systems.

3.10.2 Check of the tooth contact

a) Prior to the sea trials, the tooth surfaces of the pinions and wheels are to be coated with a thin layer of suitable coloured compound.

Upon completion of the trials, the tooth contact is to be inspected. The contact marking is to appear uniformly distributed without hard bearing at the ends of the teeth and without preferential contact lines.

The tooth contact is to comply with Table 3.1.

b) The verification of tooth contact at sea trials by methods other than that described above will be given special consideration by the Society.

c) In the case of reverse and/or reduction gearing with several gear trains mounted on roller bearings, manufactured with a high standard of accuracy and having an input torque not exceeding 20000 N.m, the check of the tooth contact may be reduced at the Society's discretion.

Such a reduction may also be granted for gearing which has undergone long workshop testing at full load and for which the tooth contact has been checked positively.

In any case, the teeth of the gears are to be examined by the Surveyor after the sea trials. Subject to the results, additional inspections or re-examinations after a specified period of service may be required.

3.11 Tests of main propulsion shafting and propellers

3.11.1 Shafting alignment

Where alignment calculations are required to be submitted, the alignment conditions are to be checked on board by the Shipyard, 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 ship:

- check of the engine (or gearbox) flanged coupling parameters (gap and sag)
- check of the crankshaft deflections before and after the connection of the engine with the shaft line, by measuring the variation in the distance between adjacent webs in the course of one complete revolution of the engine

Note 1: The ship is to be in the loading conditions defined in the alignment calculations.

c) load on the bearings:

- check of the intermediate bearing load by means of jack-up load measurements
- check of the bearing contact area by means of coating with an appropriate compound.

Table 3.1 : Tooth contact for gears

Heat treatment and machining	Percentage of tooth contact	
quenched and tempered, cut	across the whole face width	of the tooth working depth
• quenched and tempered, shaved or ground	70	40
• surface-hardened	90	40

3.11.2 Shafting vibrations

Torsional vibration measurements are to be carried out where required. The type of the measuring equipment and the location of the measurement points are to be specified.

3.11.3 Bearings

The temperature of the bearings is to be checked under the machinery power conditions.

3.11.4 Stern tube sealing gland

The stern tube oil system is to be checked for possible oil leakage through the stern tube sealing gland.

3.11.5 Propellers

a) For controllable pitch propellers, the functioning of the system controlling the pitch from full ahead to full astern position is to be demonstrated. It is also to be checked that this system does not induce any overload of the engine.

b) The proper functioning of the devices for emergency operations is to be tested during the sea trials.

3.12 Tests of piping systems

3.12.1 Hydrostatic tests of piping after assembly on board

a) When the hydrostatic tests of piping referred to in Sec. 11, 20.4.2 are carried out on board, they may be carried out in conjunction with the leak tests required in 3.12.2.

b) Low pressure pipes, such as bilge or ballast pipes are to be tested, after fitting on board, under a pressure at least equal to the maximum pressure to which they can be subjected in service. Moreover, the parts of such pipes which pass, outside pipe tunnels, through compartments for ballast water, fresh water, fuel or liquid cargo, are to be fitted before the hydraulic test of the corresponding compartments.

c) Heating coils in oil fuel tanks or in liquid cargo tanks and fuel pipes are to be subjected, after fitting on board, to a hydraulic test under a pressure not less than 1.5 times the design pressure, with a minimum of 4 bars.

3.12.2 Leak tests

Except otherwise permitted by the Society, all piping systems are to be leak tested under operational conditions after completion on board.

3.12.3 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.

3.12.4 Performance tests

The Society reserves the right to require performance tests, such as flow rate measurements, should doubts arise from the functional tests.

3.13 Tests of steering gear

3.13.1 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. 12 are fulfilled.

b) For controllable pitch propellers, the propeller pitch is to be set at the maximum design pitch approved for the maximum continuous ahead rotational speed.

c) If the ship cannot be tested at the deepest draught, alternative trial conditions will be given special consideration by the Society. In such case, the ship speed corresponding to the maximum continuous number of revolutions of the propulsion machinery may apply.

3.13.2 Tests to be performed

Tests of the steering gear are to include at least:

a) functional test of the main and auxiliary steering gear with demonstration of the performances required by Sec. 12

b) test of the steering gear power units, including transfer between steering gear power units

c) test of the isolation of one power actuating system, checking the time for regaining steering capability

d) test of the hydraulic fluid refilling system

e) test of the alternative power supply required by Sec. 12

f) test of the steering gear controls, including transfer of controls and local control

g) test of the means of communication between the navigation bridge, the engine room and the steering gear compartment

h) test of the alarms and indicators

i) where the steering gear design is required to take into account the risk of hydraulic locking, a test is to be performed to demonstrate the efficiency of the devices intended to detect this.

Note 1: Tests d) to i) may be carried out either during the mooring trials or during the sea trials.

Note 2: For ships of less than 500 tons gross tonnage and for fishing vessels, the Society may accept departures from the above list, in particular to take into account the actual design features of their steering gear.

Note 3: Azimuth thrusters are to be subjected to the above tests, as far as applicable.

4 Inspection of machinery after sea trials

4.1 General

4.1.1

a) For all types of propulsion machinery, those parts which have not operated satisfactorily in the course of the sea trials, or which have caused doubts to be expressed as to their proper operation, are to be disassembled or opened for inspection.

Machinery or parts which are opened up or disassembled for other reasons are to be similarly inspected.

b) Should the inspection reveal defects or damage of some importance, the Society may require other similar machinery or parts to be opened up for inspection.

c) An exhaustive inspection report is to be submitted to the Society for information.

4.2 Diesel engines

4.2.1

a) In general, for all diesel engines, the following items are to be verified:

- the deflection of the crankshafts
- the cleanliness of the lubricating oil filters.

b) In the case of propulsion engines for which power tests have not been carried out in the workshop, some parts, agreed upon by the interested parties, are to be disassembled for inspection after the sea trials.

Section 15 Spare Parts

1 General

1.1 In order to be able to restore engine operation and maneuvering capacity to the ship in the event of damage at sea spare parts for the main drive and the essential auxiliary machinery are to be carried on board every ship, together with the necessary tools.

These Rules are considered to be complied with if the range of spare parts corresponds to the tables given below and allowing for the extend of the installed systems and components in question at the time of commissioning.

1.2 Depending on the design and arrangement of the engine plant, the intended service and operation of the ship, and also the manufacturer's recommendations, a different volume of spare parts may be agreed between the ship owner and ACS.

Where the volume of spare parts is based on special arrangements between the ship owner and ACS, technical documentation is to be provided.

A list of the relevant spare parts is to be carried on board.

1.3 In the case of propulsion systems and essential auxiliary machinery which are not included in the following tables, the requisite range of spare parts is to be established in each individual case between shipyard/ shipowner and ACS.

2 Volume of Spare Parts

The volume of spare parts in accordance with the tables below is classified according to different ranges of service:

A = Unlimited range of service and RSA

B = All other ranges of service

Explanations:

RSA (Restricted International Service) This range of service is limited, in general, to trade along the coast, provided that the distance to the nearest port of refuge and the offshore distance do not exceed 200 nautical miles. This applies also to trade in the North Sea and within enclosed seas, such as the Mediterranean, the Black Sea and waters with similar seaway conditions. Trade to Iceland, Spitsbergen and the Azores is exempted.

RSA (Coastal Service) This range of service is limited, in general, to trade along the coasts, provided that the distance to the nearest port of refuge and the offshore distance do not exceed 50 nautical miles. This applies also to trade within enclosed seas, such as the Baltic Sea and waters with similar seaway conditions.

RSA (SW) (Sheltered Water Service) This range of service is limited to trade in shoals, bays, haffs and firths or similar waters where heavy seas do not occur.

Internal combustion engines

Table 2.1: Spare parts for main engines 1, 4, 5

Range of spare parts		A	B
Main bearings	Main bearings or shells for one bearing of each size and type fitted, complete with shims, bolts and nuts	1	-
Main thrust block (integrated)	Pads for "ahead" face of Michell type thrust block, or complete white metal thrust shoe of solid ring type	1 set	1 set
		1	1
Connecting rod bearings	Bottom end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder	1 set	-
	Crosshead type: Crosshead bearings or shells of each type complete with shims, bolts and nuts, for one cylinder	1 set	-
	Trunk piston type: Gudgeon pin complete with bush/bearing shells and securing rings for one cylinder	1 set	-
Cylinder Liner	Cylinder liner Cylinder liner, complete, fully equipped and ready for installation, including gaskets	1	-
Cylinder Cover	Cylinder cover, complete, fully equipped and ready for installations, including gaskets	1	-
	Cylinder cover bolts and nuts, for one cylinder	¼ set	-
Valves	Exhaust valves, with full equipment and ready for installation, for one cylinder	1 set	1 set
	Inlet valves, with full equipment and ready for installation, for one cylinder	1 set	1 set
	Starting air valve, with full equipment and ready for installation	1	1
	Overpressure control valve, complete	1	1
	Fuel injection valves of each type, ready for installation, for one engine [2]	1 set	¼ set
Hydraulic valve drive	High-pressure pipe/hose of each type	1	-
Piston: Crosshead type	Piston of each type, ready for fitting, with piston rod, stuffing box, piston rings, bolts and nuts	1	-
Piston: Trunk piston type	Piston of each type, ready for fitting, with piston rings, gudgeon pin, connecting rod, bolts and nuts	1	-
Piston rings	Piston rings for one cylinder	1 set	-
Piston cooling	Articulated or telescopic cooling pipes and fittings for one cylinder unit	1 set	-
Cylinder lubricator	Scope of spare parts to be defined with regard to lubricator design and subject to approval	1	-
Fuel injection pumps	Fuel injection pump complete or, when replacement of individual components at sea is practicable, complete pump element with associated valves, seals, springs, etc. or equivalent high pressure fuel pump	1	-
Fuel injection pipes	High pressure fuel pipe of each size and shape fitted, complete with couplings	1	-
Charge air system [3]	Auxiliary blower, complete including drive	1	-
	Exhaust-gas turbocharger: rotor complete with bearings, nozzle rings and attached lube oil pump	1 set	-
	Suction and pressure valves of each type for one cylinder	1 set	-
Gaskets and packings	Special gaskets and packings of each type for cylinder covers and cylinder liners, for one cylinder	-	1 set
Exhaust gas system (engine-related)	Compensator of each type	1	-

Notes

1. In the case of multi-engine installations, the minimum required spares are only necessary for one engine.
2. a) Engines with one or two fuel-injection valves per cylinder:

   one set of fuel valves, complete.

   b) Engines with more than two fuel injection valves per cylinder:

   two valves complete per cylinder plus a corresponding number of valve parts (excluding the valve bodies) which make it possible to form a complete spare set by re-using the operational parts of the dismantled valves.
3. Spare parts for exhaust-gas turbocharger and auxiliary blower may be omitted if emergency operation of the main engine after failure is demonstrably possible.

   The requisite blanking, bypass and blocking arrangements for the emergency operation of the main engine are to be available on board.
4. The necessary tools and equipment for fitting the required spare parts are to be available on board.
5. Spare parts are to be replaced immediately as soon as they are "used-up".
6. For electronically controlled engines spare parts as recommended by the engine manufacturer are to be provided.

Table 2.2 Spare parts for auxiliary engines driving electric generators for essential services

Range of spare parts		A
Main bearings	Bearings or shells for one bearing of each size and type fitted, complete with shims, bolts and nuts	1
Valves	Exhaust valves, complete with casings, seats, springs and other fittings for one cylinder	2 set
	Inlet valves, complete with casings, seats, springs and other fittings for one cylinder	1 set
	Starting air valve, complete with casing, seat, springs and other fittings	1
	Overpressure control valve, complete	1
	Fuel valves of each size and type fitted, complete, with all fittings, for one engine	¼ set
Connecting rod bearings	Bottom end bearings or shells o Connecting f each type, complete with all fittings	1
	Gudgeon pin with bush for one cylinder	1
Piston rings	Piston rings, for one cylinder	1 set
Fuel injection pumps	Fuel injection pump complete or, when replacement of individual components at sea is practicable, complete pump element with associated valves, seals, springs, etc. or equivalent high pressure fuel pump	1
Fuel injection pipes	High pressure fuel pipe of each size and shape fitted, complete with fittings	1
Gasket and packings	Special gaskets and packings of each size and type fitted, for cylinder covers and cylinder liners for one cylinder	1 set

Notes

1. Where the number of generating sets is greater than required by the Rules, (including stand-by units) no spares are required for the auxiliary engines.
2. Where several diesel engines of the same type are installed for generator drive spare parts are required for one engine only.
3. No spares are required for the engines driving emergency generator sets.
4. For electronically controlled engines spare parts recommended by the engine manufacturer are to be provided Steam turbines

Table 2.3: Spare parts for main turbines

Range of spare parts		A	B
Main bearings	Bearing shells for each size and type fitted, for the rotor	1 set	-
Thrust bearing	Pads of each size for one face of tilting pad type thrust with liners, or rings for turbine adjusting block of each size fitted, with liners	1 set	1 set
Shaft seals	Labyrinth seals, complete	1 set	-
Oil filters	Strainer baskets or inserts for filters of special design, each type and size	1 set	-

Note: In the case of twin turbine systems, spare parts are only required for one main turbine.

Table 2.4: Spare parts for auxiliary turbines driving electric generators for essential services

Range of spare parts		A	B
Main bearings	Bearing shells or roller bearings of each type and size fitted, for the turbine rotor	1 set	-
Thrust bearing	Pads for one face of tilting pad type thrust with liners, or rings for turbine adjusting block with liners	1 set	1 set
Shaft seals	Labyrinth seals, complete	1 set	-
Oil filters	Strainer baskets or inserts for filters of special design, each type and size	1 set	-

Note: Where the number of generating sets (including stand-by units) is greater than that required by the Rules, no spares are required for the auxiliary turbines.

Auxiliary prime movers

Table 2.5: Spare parts for prime movers of essential auxiliary machinery other than generators

Range of spare parts
The range of spare parts required for auxiliary drive machinery for essential consumers is to be specified in accordance with Table 2.2 or 2.4.

Note: Where an additional unit is provided for the same purpose no spare parts are required.

Steam boilers

Table 2.6: Spare parts for steam boilers

Range of spare parts	A	B
Safety valve or disc/spring combination respectively of each type	1	1
Tube plugs for each dimension of boiler and superheater tubes of each boiler	2%	2%
Glasses and gaskets for water level gauges of each boiler	1 set	1 set
Gaskets for inspection openings	1 set	1 set
Expendable parts of each firing plant consisting of burner, fuel supply, blowers, ignition facility, flame safeguard	1 set	1 set
For main steam boilers only: Complete burner or rotor with bearings of rotary cup type burners respectively	1	1

Gears, thrust bearings

Table 2.7: Spare parts for gears and thrust bearings in propulsion plants

Range of spare parts	A	B
Wearing parts of main-engine-driven pump supplying lubricating oil to gears or one complete lubricating oil pump if no stand-by pump is available	1 set 1	-
Thrust pads for ahead side of thrust bearings	1 set	1 set

Air compressor for essential services

Table 2.8: Spare parts for air compressors

Range of spare parts	A	B
Piston rings of each type and size fitted for one piston	1	1
Suction and delivery valves complete of each size and type	½set	½ set

Note: For spare parts for refrigerant compressors, see section 13 – Refrigeration Installations.

Pumps

Table 2.9: Spare parts for pumps

Range of spare parts		A	B
Piston pumps	Valve with seats and springs each size fitted	1 set	1 set
	Piston rings each type and size for one piston	1 set	1 set
	Bearing of each type and size	1	1
Centrifugal pumps	Rotor sealings of each type and size	1	1
Gear and screw type pumps	Bearings of each type and size	1	1
	Rotor sealings of each type and size	1	1

Note: Where, for a system a stand-by pump of sufficient capacity is available, the spare parts may be dispensed.

Hydraulic systems

(e.g. controllable pitch propeller systems, steering gear, windlasses, hatch cover operating systems, closing appliances in the ship's shell, watertight door closing systems, hoists)

Table 2.10: Spare parts for hydraulic systems

Range of spare parts	A	B
Pressure hoses and flexible pipes, at least one of each size	20%	20 %
Seals, gaskets	1 set	1 set

Note

For seals, this requirement is applicable only to the extent that these parts can be changed with the means available on board.

Where a hydraulic system comprises two mutually independent sub-systems, spare parts need to be supplied for one sub-system only.

Other spare parts

Table 2.11 Other spare parts for main and auxiliary engines and also for essential systems

Range of spare parts	A	B
Safety valve or one valve cone and spring of each type for pressure vessels	1	1
Hoses and compensators	20%	20%
Testing device for fuel injection valves	1	1
Tubes for condensers	2%	-
Tubes for intercooler of steam driven air ejectors	10%	-

Note

For carrying out maintenance and repair work, a sufficient number of suitable tools and special tools according to the size of the machinery installation is to be available on board.

Appendix 1 Plastic Pipes

1 General

1.1 Application

1.1.1 These requirements are applicable to plastic pipes /piping systems on ship.

1.1.2 The requirements are not applicable to flexible pipes and hoses and mechanical couplings used in metallic piping systems.

1.1.3 Piping systems made of thermoplastic materials, such as polyethylene (PE), polypropylene (PP), polybutylene (PB) and intended for non-essential services are to meet the requirements of recognized standards and of Articles 3 and 4 of this Appendix.

1.2 Use of plastic pipes

1.2.1 Plastic may be used in piping systems in accordance with the provisions of Sec 11, provided the following requirements are complied with.

1.2.2 Plastic pipes are to be type approved by the Society.

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 plastics pipes).

1.3.2 Piping systems

Pipes / piping systems means those made of plastic(s) and include the pipes, fittings, system joints, method of joining 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 2.2.3.

1.3.6 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 11, 1.2.2. It is to comply with a recognized national or international standard approved by the Society. In addition, the requirements stated below are to be complied with.

2.1.2 Marking

Plastic pipes and fittings are to be permanently marked with identification, including:

- pressure ratings
- the design standards that the pipe or fitting is manufactured in accordance with
- the material of which the pipe or fitting is made.

2.2 Strength

2.2.1 General

a) The piping is to have sufficient strength to take account of the most severe concomitant conditions of pressure, temperature, the weight of the piping itself and any static and dynamic loads imposed by the design or environment.

b) The strength of the pipes is to be determined at the maximum possible working temperature by the tests mentioned in 4.1.2.

2.2.2 Pipe thickness

Plastic pipes thickness is to be calculated using a maximum allowable stress not higher than 1/7 of the ultimate tensile strength of the material at the service temperature.

2.2.3 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 Pcol is the 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.

2.2.4 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 the Society.

b) The permissible working temperature range depends on the working pressure and is to be justified by appropriate tests.

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.

2.2.5 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 ofthe longitudinal stresses is not to exceed half of the nominal circumferential stress derived from the nominal internal pressure condition (see 2.2.3).

2.2.6 Impact resistance

Plastic pipes and joints are to have a minimum resistance to impact in accordance with a recognized 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 Table 2.1 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 indicated “L1” in Table 2.1
- 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 indicated “L2” in Table 2.1
- a 30 min fire endurance test in wet conditions is to be carried out according to Appendix 1 of IMO Res. A.753(18), where indicated “L3” in Table 2.1
- no fire endurance test is required, where indicated “0” in Table 2.1
- a metallic material with a melting point greater than 925°C is to be used, where indicated “X” in Table 2.1.

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). Other recognized national standards may also be referred to.

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).

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 from 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=10−9 siemens per meter), such as refined products and distillates, are to be made of conductive pipes.

b) Regardless of the fluid to be conveyed, plastic pipes passing through hazardous areas are to be electrically conductive.

c) Where electrical conductivity is to be ensured, the resistance of the pipes and fittings is not to exceed: 1 x 105 Ohm/m.

d) 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.

Table 2.1: Fire endurance of piping systems

PIPING SYSTEM	LOCATION										
	Machinery spaces of category A **(11)**	Other machinery spaces and pump rooms **(12)**	Cargo pump rooms **(13)**	Ro/ro cargo holds **(14)**	Other dry cargo holds **(15)**	Cargo tanks **(16)**	Fuel oil tanks **(17)**	Ballast water tanks **(18)**	Cofferdams, void spaces, pipe tunnels and ducts **(19)**	Accommodation, service and control spaces **(20)**	Open decks **(21)**
CARGO (FLAMMABLE CARGOES WITH FLASH POINT ≤ 60°C)											
Cargo lines	NA	NA	L1	NA	NA	0	NA	0 **(10)**	0	NA	L1 **(2)**
Crude oil washing lines	NA	NA	L1	NA	NA	0	NA	0 **(10)**	0	NA	L1 **(2)**
Vent lines	NA	NA	NA	NA	NA	0	NA	0 **(10)**	0	NA	X
INERT GAS											
Water seal effluent line	NA	NA	0 **(1)**	NA	NA	0 **(1)**	0 **(1)**	0 **(1)**	0 **(1)**	NA	0
Scrubber effluent line	0 **(1)**	0 **(1)**	NA	NA	NA	NA	NA	0 **(1)**	0 **(1)**	NA	0
Main line	0	0	L1	NA	NA	NA	NA	NA	0	NA	L1 **(6)**
Distribution line	NA	NA	L1	NA	NA	0	NA	NA	0	NA	L1 **(2)**
FLAMMABLE LIQUIDS (FLASH POINT > 60°C)											
Cargo lines	X	X	L1	X	X	NA **(3)**	0	0 **(10)**	0	NA	L1
Fuel oil	X	X	L1	X	X	NA **(3)**	0	0	0	L1	L1
Lubricating oil	X	X	L1	X	X	NA	NA	NA	0	L1	L1
Hydraulic oil	X	X	L1	X	X	0	0	0	0	L1	L1
SEA WATER **(1)**											
Bilge main and branches	L1 **(7)**	L1 **(7)**	L1	X	X	NA	0	0	0	NA	L1
Fire main and water spray	L1	L1	L1	X	NA	NA	NA	0	0	X	L1
Foam system	L1	L1	L1	NA	NA	NA	NA	NA	0	L1	L1
Sprinkler system	L1	L1	L3	X	NA	NA	NA	0	0	L3	L3
Ballast	L3	L3	L3	L3	X	0 **(10)**	0	0	0	L2	L2
Cooling water, essential services	L3	L3	NA	NA	NA	NA	NA	0	0	NA	L2
Tank cleaning services, fixed machines	NA	NA	L3	NA	NA	0	NA	0	0	NA	L3 **(2)**
Non-essential systems	0	0	0	0	0	NA	0	0	0	0	0
FRESH WATER											
Cooling water, essential services	L3	L3	NA	NA	NA	NA	0	0	0	L3	L3
Condensate return	L3	L3	L3	0	0	NA	NA	NA	0	0	0
Non-essential systems	0	0	0	0	0	NA	0	0	0	0	0

PIPING SYSTEM	LOCATION										
	Machinery spaces of category A (11)	Other machinery spaces and pump rooms (12)	Cargo pump rooms (13)	Ro/ro cargo holds (14)	Other dry cargo holds (15)	Cargo tanks (16)	Fuel oil tanks (17)	Ballast water tanks (18)	Cofferdams, void spaces, pipe tunnels and ducts (19)	Accommo-dation, service and control spaces (20)	Open decks (21)
SANITARY, DRAINS, SCUPPERS											
Deck drains (internal)	L1 (4)	L1 (4)	NA	L1 (4)	0	NA	0	0	0	0	0
Sanitary drains (internal)	0	0	NA	0	0	NA	0	0	0	0	0
Scuppers and discharges (over-board)	0 (1) (8)	0 (1) (8)	0 (1) (8)	0 (1) (8)	0 (1) (8)	0	0	0	0	0 (1) (8)	0
SOUNDING, AIR											
Water tanks, dry spaces	0	0	0	0	0	0 (10)	0	0	0	0	0
Oil tanks (flash point > 60°C)	X	X	X	X	X	X (3)	0	0 (10)	0	X	X
MISCELLANEOUS											
Control air	L1 (5)	L1 (5)	L1 (5)	L1 (5)	L1 (5)	NA	0	0	0	L1 (5)	L1 (5)
Service air (non-essential)	0	0	0	0	0	NA	0	0	0	0	0
Brine	0	0	NA	0	0	NA	NA	NA	0	0	0
Auxiliary low steam pressure (≤ 0,7 MPa)	L2	L2	0 (9)	0 (9)	0 (9)	0	0	0	0	0 (9)	0 (9)

Note 1: "NA" means "not applicable".

(1) Where non-metallic piping is used, remote controlled valves to be provided at ship side (valve is to be controlled from outside space).

(2) Remote closing valves to be provided at the cargo tanks.

(3) When cargo tanks contain flammable liquids with flash point > 60 °C, "0" may replace "NA" or "X".

(4) For drains serving only the space concerned, "0" may replace "L1".

(5) When controlling functions are not required by the Rules, "0" may replace "L1".

(6) For pipes between machinery space and deck water seal, "0" may replace "L1".

(7) For passenger vessels, "X" is to replace "L1".

(8) Scuppers serving open decks in positions 1 and 2, as defined in Part 3, Ch.1, Sec. 1/1.16, are to be "X" throughout unless fitted at the upper end with a means of closing capable of being operated from a position above the freeboard deck in order to prevent downflooding.

(9) For essential services, such as fuel oil tank heating and ship's whistle, "X" is to replace "0".

(10) For tankers required to comply with Part 5, Ch. 7, "NA" is to replace "0".

(11) Machinery spaces of category A are defined in Part 3, Ch. 3, Sec. 2/1.2.

(12) Spaces, other than category A machinery spaces and cargo pumps 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.

(13) Spaces containing cargo pumps, and entrances and trunks to such spaces.

(14) Ro-ro cargo spaces and special category spaces are defined in Ch 4, Sec 1, 3.

(15) All spaces other than ro-ro cargo holds used for non-liquid cargo and trunks to such spaces.

(16) All spaces used for liquid cargo and trunks to such spaces.

(17) All spaces used for fuel oil (excluding cargo tanks) and trunks to such spaces.

(18) All spaces used for ballast water and trunks to such spaces.

(19) Empty spaces between two bulkheads separating two adjacent compartments.

(20) Accommodation spaces, service spaces and control stations are defined in Ch 4, Sec 1, 3.

(21) Open decks are defined in Ch 4, Sec 1, 3.

2.4 Pipe and fitting connections

2.4.1 General

a) The strength of connections is not to be less than that of the piping system in which they are installed.

b) Pipes and fittings may be assembled using adhesive bonded, welded, flanged or other joints.

c) When used for joint assembly, adhesives are to be suitable for providing a permanent seal between the pipes and fittings throughout the temperature and pressure range of the intended application.

d) Tightening of joints, where required, is to be performed in accordance with the manufacturer's instructions.

e) Procedures adopted for pipe and fitting connections are to be submitted to the Society for approval, prior to commencing the work.

2.4.2 Bonding of pipes and fittings

a) The procedure for making bonds is to be submitted to the Society 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 by the Shipyard in accordance with the Manufacturer's guidelines and taking account of the following provisions, as deemed necessary.

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 minimize 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.

3.5 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 $1 \times 10^6\,\Omega$.

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 When plastic pipes pass through watertight bulkheads or decks, the watertight integrity of the bulkhead or deck is to be maintained. If the bulkhead or deck is also a fire division and destruction by fire of plastic pipes may cause the inflow of liquid from tanks, a metallic shut-off valve operable from above the freeboard deck is to be fitted at the bulkhead or deck.

3.7 Systems connected to the hull

3.7.1 Bilge and sea water systems

a) Where, in pursuance of 2.3.1, plastic pipes are permitted in bilge and sea water systems, the ship side valves required in Sec 11, 2.8 and, where provided, the connecting pipes to the shell are to be made of metal in accordance with Sec 11, 2.1.

b) Ship side valves are to be provided with remote control from outside the space concerned. See Table 2.1, 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 Table 2.1, footnotes (1) and (8).

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 and fittings are to be of a type approved by the Society for the intended use. For this purpose, the material tests required in 4.1.2 and, where applicable, the bonding qualification test detailed in 4.1.3 are to be performed.

4.1.2 Material tests

a) Tests are to be performed according to a procedure approved by the Society to determine, for each type of pipe and fitting, the following characteristics:

- ultimate tensile strength
- short-term and long-term design strength
- collapse
- impact resistance
- fire endurance
- low flame spread characteristics
- electrical resistance (for electrically conductive pipes).

For the above tests, representative samples of pipes and fittings are to be selected to the satisfaction of the Society.

b) The ultimate tensile strength is to be determined by means of a hydrostatic test on pipe samples subjected to increasing pressure up to failure, the pressure being increased at such a rate that failure occurs in not less than 5 minutes. Such test is to be carried out under the standard conditions: atmospheric pressure equal to 100kPa, relative humidity 30%, environmental and carried fluid temperature 298 K (25°C).

The ultimate tensile strength is to be determined using the tangential stress based on the initial diameter of the pipe. Small deformations of the pipe sample during the test may be accepted.

c) Alternatively, hydrostatic test failure pressure and collapse pressure may be determined by a combination of tests and calculations, subject to the agreement of the Society.

d) After the impact resistance test, the specimen is to be subjected to hydrostatic pressure equal to 2,5 times the design pressure for at least 1 hour.

4.1.3 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 Quality control during manufacture

4.2.1 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.

In case the Manufacturer does not have an approved quality system complying with ISO 9000 series or equivalent, pipes and fittings are to be tested in accordance with this Appendix to the satisfaction of the Classification Society's surveyors for every batch of pipes.

4.2.2 Each pipe and fitting is to be tested by the Manufacturer at a hydrostatic pressure not less than 1.5 times the nominal pressure. Alternatively, for pipes and fittings not employing hand lay up techniques, the hydrostatic pressure test may be carried out in accordance with the hydrostatic testing requirements stipulated in the recognised national or international standard to which the pipe or fittings are manufactured, provided that there is an effective quality system in place.

Depending upon the intended application the Society may require the pressure testing of each pipe and/or fitting.

Table 4.1: Typical requirements for all systems

Nr	Test	Typical standard	Notes
1	Internal pressure (1)	the present 2.2.3, item a) ASTM D 1599 ASTM D 2992 ISO 15493 or equivalent	Top, middle, bottom (of range) Tests are to be carried out on pipe spools made of different pipe sizes, fittings and pipe connections
2	External pressure (1)	the present 2.2.3, item b) ISO 15493 or equivalent	As above, for straight pipes only
3	Axial strength	the present 2.2.5	As above
4	Load deformation	ASTM D 2412 or equivalent	Top, middle, bottom (of each pressure range)
5	Temperature limitations	ISO 75 method A GRP piping system: HDT test on each type of resin according to ISO 75 method A Thermoplastic piping systems: ISO 75 method A ISO 306 - Thermoplastic materials - Determination of Vicat softening temperature (VST) VICAT test according to ISO 2507 Polyesters with an HDT below 80°C should not be used	Each type of resin
6	Impact resistance	ISO 9854: 1994, ISO 9653: 1991, ISO 15493, ASTM D 2444, or equivalent	Representative samples of each type of construction
7	Ageing	Manufacturer's standard ISO 9142: 1990	Each type of construction
8	Fatigue	Manufacturer's standard or service experience	Each type of construction
9	Fluid absorption	ISO 8361: 1991	
10	Material compatibility (2)	ASTM C581 Manufacturer's standard	

(1) Test to be witnessed by a Surveyor of the Society.

(2) If applicable.

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.

4.4 Test specification for plastic pipes

4.4.1 Scope

This sub-article contains requirements for the type approval of plastic pipes. Unless otherwise specified, it is applicable to rigid pipes, pipe joints and fittings.

4.4.2 Documentation

The following information for the plastic pipes, fittings and joints is to be submitted for consideration and approval:

a) General information

- pipe and fitting dimensions
- maximum internal and external working pressure
- working temperature range
- intended services and installation locations
- the level of fire endurance
- electrically conductive
- intended fluids
- limits on flow rates
- serviceable life
- installation instructions
- details of marking.

b) Drawings and supporting documentation

- certificates and reports for relevant tests previously carried out
- details of relevant standards
- all relevant design drawings, catalogues, data sheets, calculations and functional descriptions
- fully detailed sectional assembly drawings showing pipe, fittings and pipe connections.

c) Materials

- the resin type
- catalyst and accelerator types, and concentration employed in the case of reinforced polyester resin pipes or hardeners where epoxide resins are employed
- a statement of all reinforcements employed where the reference number does not identify the mass per unit area or the tex number of a roving used in a filament winding process, these are to be detailed
- full information regarding the type of gel-coat or thermoplastic liner employed during construction, as appropriate
- cure/post-cure conditions. The cure and post-cure temperatures and times employ resin/reinforcement ratio
- winding angle and orientation.

4.4.3 Testing

Testing is to demonstrate compliance of the pipes, fittings and joints for which type approval is sought with the present Appendix.

Pipes, joints and fittings are to be tested for compliance with the requirements of recognized standards acceptable to the Society. In that order, recommended standards are given in Table 4.1 and Table 4.2.

Table 4.2: Typical additional requirements depending on service and/or locations of piping

Nr	Test	Typical Standard	Notes
1	Fire endurance (1) (2) (3)	IMO Res. A753(18), Appendix 1, 2	Representative samples of each type of construction and type of pipe connection
2	Flame spread (1) (2) (3)	the present 2.3.2	Representative samples of each type of construction
3	Smoke generation (2)	IMO Fire Test Procedures Code	Representative samples of each type of construction
4	Toxicity (2)	IMO Fire Test Procedures Code	Representative samples of each type of construction
5	Electrical conductivity (1) (2) (3)	ASTM F1173-95 or ASTM D 257, NS 6126 § 11.2 or equivalent	Representative samples of each type of construction

(1) Test to be witnessed by a Surveyor of the Society.

(2) If applicable

(3) Optional. However, if the test is carried out, the range of approved applications for the pipes is to be limited accordingly

Appendix 2 Independent Fuel Oil Tanks

1 General

1.1 Application

1.1.1

a) The provisions of this Appendix apply to fuel oil tanks and bunkers which are not part of the ship's structure.

b) Requirements for scantling apply only to steel tanks.

Scantling of tanks not made of steel will be given special consideration.

1.2 Documents to be submitted

1.2.1 Constructional drawings of the tanks are to be submitted, showing the height of the overflow and air pipe above the top of the tank.

1.3 Symbols and units

1.3.1 Tanks

The meaning of the symbols used for tanks is given in Figure 1.1.

L : Greater length of the considered plating element, in m

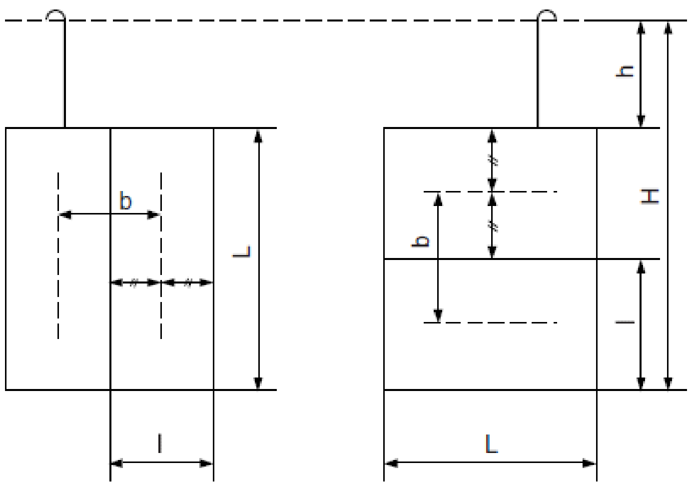
l : Smaller length of the considered plating element, in m

H : Height, in m, of the overflow or air pipe above the lower edge of the considered plating element

h : Height, in m, of overflow or air pipe above the top of the tank, subject to a minimum of:

- 3.60 m for fuel oil having a flash point below 60°C
- 2.40 m otherwise.

Figure 1.1: Symbols used for tanks



1.3.2 Stiffeners

The following symbols and units are used for the stiffeners:

b : Width of the plating element supported by the stiffener, in m

w : Section modulus of the stiffeners, in cm3.

2 Design and installation of tanks

2.1 Materials

2.1.1 General

Independent fuel oil tanks are to be made of steel except where permitted in 2.1.2.

2.1.2 Use of materials other than steel

a) On ships of less than 100 tons gross tonnage, independent fuel oil tanks may be made of:

- aluminium alloys or equivalent material, provided that the tanks are located outside the propulsion machinery spaces or, when located within such spaces, they are insulated to A-60 class standard
- glass reinforced plastics (GRP), provided:
  - the total volume of tanks located in the same space does not exceed 4.5 m^3, and
  - the properties of GRP including fire resistance comply with the relevant provisions of App1.

b) On ships of 100 tons gross tonnage or more, the use of independent fuel oil tanks made of aluminium alloys or GRP will be given special consideration.

2.2 Scantling of steel tanks

2.2.1 General

a) The scantling of tanks whose dimensions are outside the range covered by the following provisions will be given special consideration.

b) The scantling of the tanks is to be calculated assuming a minimum height h of the overflow or air pipe above the top of the tank of:

- 3.60 m for fuel oil having a flash point below 60°C
- 2.40 m otherwise.

c) All tanks having plating elements of a length exceeding 2.5 m are to be fitted with stiffeners.

2.2.2 Thickness of plating

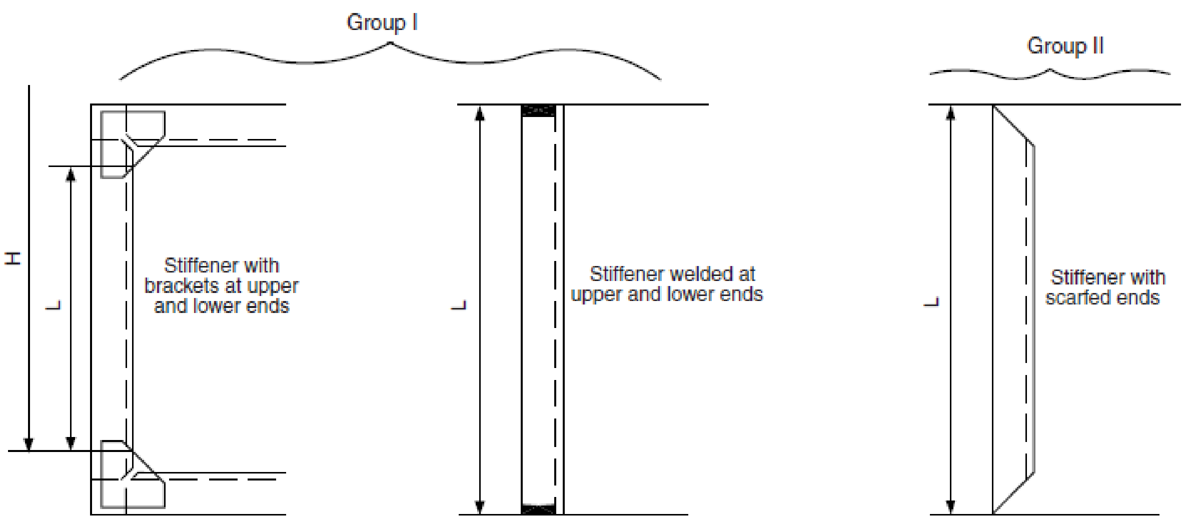
The thickness of the plates is not to be less than the value given in Table 2.1 for the various values of l, L/l and H.

However, for tanks having a volume of more than 1 m^3, the thickness of the plates is not to be less than 5 mm.

Table 2.1: Thickness of plating (mm)

l (m)	L / l	H (m) 2,4 - 2,7	2,7 - 3,0	3,0 - 3,3	3,3 - 3,6	3,6 - 4,0	4,0 - 4,4	4,4 - 4,8	4,8 - 5,2	5,2 - 5,8	5,8 - 6,4	6,4 - 7,0	7,0 - 8,0	8,0 - 9,0	9,0 - 10,0
0,40	< 2	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,5	3,5	3,5	4,0	4,0	4,0	4,5
	≥ 2	3,0	3,0	3,0	3,5	3,5	3,5	4,0	4,0	4,0	4,5	4,5	5,0	5,0	5,5
0,45	< 2	3,0	3,0	3,0	3,0	3,0	3,5	3,5	3,5	4,0	4,0	4,0	4,5	4,5	5,0
	≥ 2	3,5	3,5	3,5	4,0	4,0	4,0	4,5	4,5	4,5	5,0	5,0	5,5	6,0	6,0
0,50	< 2	3,0	3,0	3,5	3,5	3,5	4,5	4,5	5,0	5,0	5,5	5,5	6,0	6,5	7,0
	≥ 2	3,5	4,0	4,0	4,0	4,5	4,5	4,5	5,0	5,0	5,5	5,5	6,0	6,5	7,0
0,55	< 2	3,5	3,5	3,5	4,0	4,0	4,0	4,0	4,5	4,5	5,0	5,0	5,5	5,5	6,0
	≥ 2	4,0	4,5	4,5	4,5	4,5	5,0	5,0	5,5	5,5	6,0	6,0	6,5	7,0	7,5
0,60	< 2	3,5	4,0	4,0	4,0	4,0	4,5	4,5	4,5	5,0	5,0	5,5	5,5	6,0	6,5
	≥ 2	4,5	4,5	4,5	5,0	5,0	5,5	5,5	6,0	6,0	6,5	6,5	7,0	7,5	8,0
0,65	< 2	4,0	4,0	4,0	4,0	4,5	4,5	5,0	5,0	5,5	5,5	6,0	6,0	6,5	7,0
	≥ 2	4,5	5,0	5,0	5,0	5,5	6,0	6,0	6,5	6,5	7,0	7,5	7,5	8,5	8,5
0,70	< 2	4,0	4,0	4,5	4,5	5,0	5,0	5,0	5,5	5,5	6,0	6,5	6,5	7,0	7,5
	≥ 2	5,0	5,0	5,5	5,5	6,0	6,5	6,5	7,0	7,0	7,5	8,0	8,5	9,0	–
0,75	< 2	4,5	4,5	5,0	5,0	5,0	5,5	5,5	6,0	6,0	6,5	6,5	7,0	7,5	8,0
	≥ 2	5,5	5,5	6,0	6,0	6,5	6,5	7,0	7,5	7,5	8,0	8,5	9,0	–	–
0,80	< 2	4,5	5,0	5,0	5,0	5,5	6,0	6,0	6,0	6,5	7,0	7,0	7,5	8,0	8,5
	≥ 2	5,5	6,0	6,0	6,5	6,5	7,0	7,5	7,5	8,0	8,5	9,0	–	–	–
0,85	< 2	5,0	5,0	5,5	5,5	5,5	6,0	6,5	6,5	7,0	7,0	7,5	8,0	8,5	9,0
	≥ 2	6,0	6,5	6,5	7,0	7,0	7,5	8,0	8,0	8,5	9,0	–	–	–	–
0,90	< 2	5,0	5,5	5,5	6,0	6,0	6,5	6,5	7,0	7,0	7,5	8,0	8,5	9,0	–
	≥ 2	6,5	6,5	7,0	7,0	7,5	8,0	8,5	8,5	9,0	–	–	–	–	–
0,95	< 2	5,5	5,5	6,0	6,0	6,5	7,0	7,0	7,5	7,5	8,0	8,5	9,0	–	–
	≥ 2	6,5	7,0	7,0	7,5	8,0	8,5	9,0	9,0	–	–	–	–	–	–
1,00	< 2	5,5	6,0	6,0	6,5	7,0	7,0	7,5	7,5	8,0	8,5	9,0	–	–	–
	≥ 2	7,0	7,5	7,5	8,0	8,5	8,5	9,0	–	–	–	–	–	–	–

Figure 2.1: Type of stiffener end attachments



2.2.3 Scantlings of stiffeners

a) This requirement applies only to stiffeners which are all vertical or all horizontal and attached according to the types shown in Figure 2.1. Other cases will be given special consideration.

b) The minimum values of the ratio w/b required for stiffeners are given in:

- Table 2.2 for vertical stiffeners
- Table 2.3 for horizontal stiffeners

for the different types of attachments shown in Figure 2.1.

2.3 Installation

2.3.1 Securing

Independent tanks are to be securely fixed to hull structures and are to be so arranged as to permit inspection of adjacent structures.

2.3.2 Protection against spillage

Where permitted, independent fuel oil tanks are to be placed in an oil-tight spill tray of ample size with a suitable drain pipe leading to a suitably sized spill oil tank.

Table 2.2: Values of w/b ratio for vertical stiffeners (cm^3/m)

L (m)	end attachment	H, in m (1)												
		3,0	3,3	3,6	3,9	4,3	4,6	5,0	5,5	6,0	7,0	8,0	9,0	10,0
0,6	I	5,0	5,5	6,0	6,5	7,5	8,0	9,0	9,5	10,5	11,5	14,0	16,0	18,0
	II	8,0	9,0	10,0	11,0	12,0	12,5	13,0	15,0	16,0	19,0	22,0	25,0	28,0
0,8	I	8,5	9,5	10,5	11,5	13,0	14,0	15,0	16,5	18,0	22,0	25,0	28,0	31,5
	II	13,0	15,0	16,0	18,0	20,0	21,5	24,0	25,5	28,5	34,0	38,0	43,0	48,0
1,0	I		14,5	16,0	17,5	19,5	21,0	23,0	26,0	28,5	34,0	38,0	43,0	49,0
	II		22,0	24,0	27,0	30,0	32,5	36,0	39,0	43,0	51,0	58,0	67,0	75,0
1,2	I			22,5	24,5	28,0	30,0	33,0	37,0	40,5	48,0	55,0	63,0	71,0
	II			34,0	30,7	42,5	46,0	50,0	55,0	61,0	73,0	84,0	96,0	107
1,4	I			30,0	32,5	37,0	40,0	44,0	49,0	55,0	65,0	75,0	85,0	96,0
	II			45,0	49,0	56,0	61,0	67,0	74,0	82,0	98,0	113,0	129,0	144,0
1,6	I				47,0	53,0	57,0	64,0	71,0	79,0	94,0	110,0	125,0	140,0
	II				71,0	80,0	87,0	96,0	107,0	118,0	141,0	165,0	187,0	
1,8	I				58,0	65,0	71,0	79,0	88,0	98,0	117,0	136,0	156,0	175,0
	II				87,0	98,0	107,0	118,0	132,0	147,0	176,0	204,0		
2,0	I					78,0	85,0	95,0	107,0	119,0	142,0	166,0	190,0	
	II					118,0	129,0	142,0	160,0	178,0				
2,2	I						100,0	112,0	126,0	140,0	170,0	198,0		
	II						151,0	168,0	190,0					
2,5	I						124,0	139,0	158,0					
	II						187,0							

(1) H is to be taken equal to the height of the tank top above the lower end of the stiffener, plus h.

Table 2.3: Values of w/b ratio for horizontal and top and bottom stiffeners (cm^3/m)

L (m)	end attach-ment	H, in m (1)															
		2,4	2,6	2,8	3,0	3,3	3,6	3,9	4,3	4,6	5,0	5,5	6,0	7,0	8,0	9,0	10,0
0,6	I	4,5	5,0	5,5	6,0	6,5	7,0	7,5	8,5	9,0	10,0	11,0	12,0	13,5	15,0	17,0	19,0
	II	7,0	8,0	8,5	9,0	10,0	11,0	11,5	12,5	13,5	15,0	16,0	17,5	21,0	24,0	27,0	30,0
0,8	I	8,0	9,0	9,5	10,0	11,0	12,0	13,0	14,5	15,5	17,0	18,5	20,0	23,5	27,0	30,0	33,5
	II	13,0	15,0	15,5	16,5	18,0	19,5	21,5	23,5	25,0	27,0	30,0	34,0	38,0	44,0	49,0	55,0
1,0	I	13,0	15,0	15,5	16,5	18,0	19,5	21,5	23,5	25,0	27,0	30,0	34,0	38,0	44,0	49,0	55,0
	II	20,0	22,0	23,5	25,0	28,0	30,0	33,0	36,0	39,0	42,0	46,0	50,0	59,0	67,0	75,0	84,0
1,2	I	18,0	20,0	21,0	22,5	25,0	26,5	29,5	32,5	34,5	37,5	41,5	45,0	52,5	60,0	67,5	75,0
	II	28,0	31,0	33,0	35,0	39,0	42,0	46,0	51,0	54,0	59,0	65,0	70,0	82,0	93,0	105	117
1,4	I	26,0	28,0	30,5	32,5	36,0	39,0	42,5	46,5	50,0	54,5	59,5	65,0	76,0	87,0	97,0	108
	II	39,0	43,0	45,5	49,0	54,0	58,5	63,5	70,0	75,0	81,0	89,0	97,0	113	130	146	162
1,6	I	36,0	39,0	42,0	45,0	50,0	54,0	59,0	65,0	69,0	75,0	82,0	90,0	105	120	135	150
	II	56,0	61,0	66,0	70,0	77,0	84,0	91,0	100	107	117	128	140	163	186		
1,8	I	46,0	50,0	54,0	58,0	63,0	69,0	75,0	82,0	88,0	95,0	105	115	134	153	172	191
	II	70,0	76,0	82,0	88,0	96,0	105	113	125	134	146	160	175	204			
2,0	I	57,0	62,0	67,0	72,0	78,0	85,0	92,0	102	109	118	130	142	166	190		
	II	87,0	95,0	102	109	120	130	141	155	166	181	198					
2,2	I	70,0	76,0	82,0	88,0	96,0	105	113	125	134	145	160	175	204			
	II	107	116	125	134	147	160	174	192	205							
2,5	I	92,0	100	108	115	127	138	150	165	176	191						
	II	140	152	163	175	192											

(1) For horizontal stiffeners, H is to be measured from the horizontal stiffener immediately below the stiffener considered. For top stiffeners, H = h.

Chapter 2 Electrical Installations

Section 1 Service Description

1 Application

1.1 General

1.1.1 Purpose

a) The rules in this chapter apply to electrical installations for assignment of main class. Rules dealing with safety for personnel, fire and explosion hazards do apply to all types of electrical installations that are installed on board.

b) Requirements dealing with availability of electrical power supply apply to electrical installations serving essential or important services.

c) For installations of less than 100 kVA total main generator capacity, the Society may apply modified rules for both technical requirements and for the verification process. Information on modified requirements shall be agreed upon in each case and shall be made available for the operational phase.

d) Portable electric appliances are not covered by the scope of classification.

1.1.2 Supplementary requirements

Supplementary requirements will be enforced for vessels with additional class notations, as required by the respective parts of the rules.

1.1.3 IEC standards

a) The requirements in this chapter are generally based on applicable standards for ships as issued by IEC (the International Electrotechnical Commission).

b) Where direct reference is made to such standards, it is meant the standard(s) in force at the time of contract between yard and owner.

This implies primarily the IEC 60092 series for ships.

1.1.4 Other standards

a) The Society will consider the use of alternative standards if they are found to represent an overall safety concept equivalent to that of the rules.

b) Acceptance of the use of other standards may be given without yard’s or owner's or operator’s consent. An application for acceptance of other standards shall be submitted. Upon request, a copy of an English version of the standard shall be submitted.

Special care should be taken when requirements from different standards are used within the same system.

1.1.5 Alternative solutions

a) Alternative solutions to the requirements in the rules will be accepted by the Society when found to represent the same level of safety and availability as the solutions required by these rules. Such an acceptance may be given without yard's, owner's or operator's consent.

b) Verification additional to that required by the rules may be necessary when alternative solutions are proposed. It is the obligation of the party applying for using alternative solution to ensure yard's agreement to additional verification onboard.

2 Verification Scheme

2.1 General

2.1.1 Work processes

a) As a basis for assignment of class, the Society will verify that the electrical installation complies with the relevant rule requirements. This verification process is organized as follows:

- approval of system design
- equipment certification
- onboard survey.

b) The verification process is carried out on a spot check basis. The full responsibility for compliance with the applicable rules lies with the yard or any other contractually bound party.

c) The verification process includes requirements to approval of:

- systems (including distribution systems)
- equipment
- components.

For standard designs the case by case approval may be replaced by the type approval scheme.

2.2 Plan approval

2.2.1 Documentation related to system design shall be submitted as required by Table 2.1.

Table 2.1: System design, documentation requirements

Object	Documentation type	Additional description	For approval (AP) for Information(FI) on request (R)
Electric power systems	Overall single line diagram		AP
	Single line diagrams/ consumer list for switchboards	For: — AC power systems — DC battery systems — UPS systems	AP
	Electrical consumption Balance	For: — AC power systems — DC battery systems — UPS systems	AP
	Electrical system philosophy	System philosophy may not be required if the "overall single line diagram" is sufficient to give necessary understanding of the operation and relevant operation modes of the system.	FI
	Short circuit calculations		FI
	Harmonic distortion Calculations	Required when more than 20% of connected load is by semi-conductor assemblies, in relation to connected generating capacity.	FI
	Voltage drop calculations	Upon request and when a motor rated above 30% of the feeding generator(s) or transformer(s) rated power is started direct on line.	FI,R
	Discrimination analysis	The document shall cover: — generator protection — main switchboard circuits — emergency switchboard circuits — battery and UPS systems	AP
	Arrangement plan	Including locations of power sources, switchboards and distribution boards for main and emergency power, UPSs and batteries. Arrangement of access doors, fire divisions and high fire risk areas related to the above.	FI
	Failure mode and effect analysis	Required if separate emergency source of power is omitted in accordance with Sec.2, 3.1.4. Upon request for other systems.	AP
	Test procedure for quay and sea trial	Redundancy and failure modes based on FMEA. Required if separate emergency source of power is omitted in accordance with Sec.2, 3.1.4. Upon request for other systems.	AP
Motor starters	Electrical schematic drawing	Starters for essential services.	AP
Cables	Cable selection philosophy	Applicable for: — Vessels following the HSLC — Passenger vessels	AP
Emergency stop system	Electrical schematic drawing	Emergency stop of electrical propulsion motors, pumps and fans, showing fail to safe functionality.	AP
Installation in hazardous areas	Table of Ex-installation	Based on approved area classification drawing and ESD philosophy (if relevant).	AP
Installation in hazardous areas	Hazardous area classification drawing	An approved Area classification drawing where location of electric equipment in hazardous area is added (Except battery room, paint stores and gas bottle store).	FI
Lighting systems	Lighting description	Applicable for: — Vessels following the HSLC — Passenger vessels — Vessels equipped with a bow loading system	AP
	System arrangement plan	Emergency lighting arrangement	AP

2.2.2 Electrical equipment required to be delivered with ACS Product Certificate, see Table 2.3, shall be documented as described in Table 2.2. For equipment covered by a valid ACS type approval certificate, this certificate may specify exceptions to document approval.

Table 2.2: Component certification, documentation requirements

Object	Documentation type	Additional description	For approval (AP) For Information(FI)
Cables	Cable data sheet and design drawing	For cables not having a ACS type approval.	AP
Electric propulsion motors	Shafting documentation	Shafting for electric propulsion motors in mechanical propulsion line.	AP
Shaft generators	Shafting documentation	Shafting for electric generators in mechanical propulsion line	AP
Main and emergency switchboards	Electrical data sheet, general		FI
	Assembly schedules and technical data		AP
	Strength calculation with respect to short circuit	When designed sub-transient short circuit strength exceeds 50 kA r.m.s.	FI
	Internal arc withstanding report	High voltage switchboards only.	FI
	Electrical schematic drawing		AP
	Layout of electrical assembly		FI
	Functional description for electrical assemblies		FI
Semi-conductor assemblies	Electrical data sheet, general		AP
	Electrical data sheet, semiconductor assemblies		FI
	Assembly schedules and technical data		AP
	Layout of electrical assembly		FI
	Functional description for electrical assemblies		FI
	Test procedure at manufacturer		AP
Distribution switchboards, motor starters, motor control centres, harmonic filters etc.	Electrical data sheet, general		AP
	Assembly schedules and technical data		AP
	Strength calculation with respect to short circuit	When designed sub-transient short circuit strength exceeds 50 kA r.m.s.	FI
	Internal arc withstanding report	High voltage switchboards only.	FI
	Electrical schematic drawing		AP
	Layout of electrical assembly		FI
Systems for automatic start and stop of generator drivers and for automatic operation of breakers.	Control system functional description		AP
	Block diagram		AP
	Power supply arrangement		AP
	Data sheet with environmental specifications		AP
	Test procedure at manufacturer		AP

2.2.3 For general requirements to documentation, see Part 1 Ch.1.

2.3 Equipment certification

2.3.1 Required certificates

a) All electrical equipment serving essential or important functions shall be delivered with ACS Product certificate or ACS Type Approval Certificate as required by Table 2.3.

b) All cables shall be delivered with ACS Product certificate or ACS Type Approval Certificates as required by Table 2.3. Exempted cables are listed in the note 3 of Table 2.3.

c) Additional requirements for certification may be given by other relevant parts of the rules.

d) Equipment covered by a valid type approval certificate is generally accepted without design assessment, unless otherwise stated in the certificate. A copy of the type approval certificate will substitute the required documentation for ACS design assessment.

e) A product certificate may be issued based on the type approval certificate and a product survey, unless otherwise stated in the type approval certificate.

2.3.2 Product survey

a) A product survey is performed as part of the certification process. The survey normally includes:

- review of the manufacturers documentation
- documentation of results from type tests shall, if performed, be available.
- visual inspection
- testing.

b) Visual inspection shall verify that:

- manufacturing and installation is in accordance with the approved design information as required by Table 2.2
- the product manufacturing is in accordance with the requirements in the relevant equipment section of the rules
- general craftsmanship is acceptable.

c) The extent of the manufacturer’s testing shall be as required by applicable sections of the rules. The testing shall be performed in accordance with approved test program when required by Table 2.2. Test results shall be recorded and filed.

Table 2.3: Required certificates

Equipment	Continuous rating	ACS product certificate	Works certificate [1]	ACS type approval certificate
Main and emergency switchboards	all ratings	X		
Distribution switchboards, motor starters, motor control centres, etc.	≥100 kW/kVA	X		
	≥10 kW/kVA and <100 kW/kVA		X	
Generators [4] and transformers	≥300 kVA	X		
	≥100 kVA and <300 kVA [2]	X		
	≥10 kVA and <100 kVA		X	
Motors [4]	≥300 kW			
	≥100 kW and <300 kW [2]	X		
	≥10 kW and <100 kW		X	
Semi-conductor converters for motor drives	≥100 kW	X [7]		
	≥10 kW and <100 kW		X	
Semi-conductor converters for motor drives	≥50 kVA	X [8]		
	<50 kVA		X	
Cables [3), 6]	all ratings			X
System for automatic start/stop of generator prime movers and automatic operation of breakers [5]	all ratings	X		

1) Work certificate can be required when necessary for further information.

2) As an alternative to the acceptance based on ACS product certificate, the electrical equipment will also be accepted based on a ACS type approval certificate and work certificate.

3) All cables, except:

- cables for internal use in electrical assemblies
- short cable lengths on mechanical packages
- control, automation and communication cables for non-important equipment

4) Certificates for shafts shall be issued as required by rules. This is only applicable for shafts part of the main mechanical propulsion line except generators in diesel electrical propulsion.

5) See Ch.3 for requirement to documentation and scope of testing.

6) Cables not having valid type approval certificate will also be accepted on the basis of a ACS product certificate.

For manufactures having type approved cables, only routine tests will be required.

7) Certification of semiconductor converters for motor drives may be partly based on type approval of power modules.

8) Semi-conductor converters/assemblies for power supply may be covered by a Type Approval certificate. This will be stated in the Type Approval certificate.

Note: Heat exchangers used in conjunction with certified electrical equipment, shall be certified as required for pressure vessels, see Ch.1, Sec. 5.

2.4 Onboard survey

2.4.1 General

Onboard survey shall be performed as part of the classification process, and focuses on the installation on board as well as on the functionality of the electrical system.

2.4.2 Onboard inspections

Onboard inspections shall be performed in order to evaluate that:

- the electrical installation is in accordance with the accepted or approved information
- the electrical installation is in accordance with the requirements in the rules
- the craftsmanship is acceptable.

2.4.3 Function tests

Function tests are part of the Society's verification of the installation's compliance with the requirements in the rules and approved documentation.

2.4.4 Available documentation

During onboard survey, the following documentation shall be available for the Society's surveyor:

- approved design documentation and documentation submitted for information as required by 2.3.2
- ACS certificates for equipment required certified
- approved area classification drawing and ESD philosophy where relevant
- applicable Ex certificates
- manufacturer's declaration for non-certified equipment that is installed in a hazardous area
- additional documentation where deemed necessary to assess the installations' compliance with the rules
- cable routing arrangement.

Section 2 System Design

1 General

1.1 Design principle

1.1.1 General requirements

a) Electrical installations shall be such that the safety of passengers, crew and ship, from electrical hazards, is ensured. (Interpretation of SOLAS Ch. II-1/40.1.3)

b) There shall be two mutually independent and self contained electric power supply systems on board:

- main electric power supply system
- emergency electric power supply system. Exceptions are given in 3.1.1 and 3.1.4. (Interpretation of SOLAS Ch. II-1/40.1.2 and 43.1.1)

c) Services required for normal operation of the vessel shall be operable with the emergency electrical power generation and distribution system being unavailable, unless such services are permitted to be powered by emergency electrical power supply only.

d) All consumers that support functions required to be available in normal operation, shall be supplied from distribution systems independent of the emergency electrical power supply system. Exemptions are made for one of redundant consumers required for dead ship recovery.

e) All consumers required to be available in emergency operation shall be supplied from distribution systems independent of the main electric power supply system.

f) Consumers required having both main and emergency supply shall be supplied as required by relevant rules applicable for these consumers. The primary supply shall be from the main system.

g) Vessels without a dedicated emergency electric power supply system are accepted upon compliance with requirements in 3.1.4.

Requirements to arrangements of main and emergency power supply systems with respect to fire, flooding or other casualty are given in 9.1.2.

1.1.2 Environmental conditions

a) The electrical installations shall be suitable for operation in those environmental conditions given in Sec.3, 2, and have an ingress protection rating as given in Sec.10, 2.2, except as stated in b) and c).

b) Where electrical equipment is installed within environmentally controlled spaces the ambient temperature for which the equipment shall be suitable may be reduced from 45°C and maintained at a value not less than 35°C provided:

- the equipment is not for use for emergency services, and shall not be in operation after ESD has been activated

- temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is capable of satisfactorily maintaining the design temperature
- the equipment can be started in a 45°C ambient temperature and kept in operation until the lesser ambient temperature may be achieved
- the cooling equipment shall be rated for a 45°C ambient temperature
- malfunction of, or loss of a cooling unit shall be alarmed at a manned control station.

In accepting a lesser ambient temperature than 45°C, it shall be ensured that electrical cables for their entire length are adequately rated for the maximum ambient temperature to which they are exposed along their length.

c) The equipment used for cooling and maintaining the lesser ambient temperature is an important service, in accordance with Sec.13, 1.3.2 and shall comply with the relevant rules.

(IACS UR E19)

For the requirements for ventilation and air conditioning, see 9.1.1.

1.1.3 System earthing

a) System earthing shall be effected by means independent of any earthing arrangements of the non-current carrying parts.

b) Any earthing impedances shall be connected to the hull. The connection to the hull shall be so arranged that any circulating current in the earth connections do not interfere with radio, radar, communication and control equipment circuits. (IACS UR E11, 2.1.4)

c) If the system neutral is connected to earth, suitable disconnecting links or terminals shall be fitted so that the system earthing may be disconnected for maintenance or insulation resistance measurement. Such means shall be for manual operation only.

d) If the system neutral is connected to earth at several points, equalising currents in the neutral earthing exceeding 20% of the rated current of connected generators or transformers is not acceptable. Transformer neutrals and generator neutrals shall not be simultaneously earthed in the same distribution system at same voltage level. On distribution transformers with star connected primary side, the neutral point shall not be earthed.

e) In any four wire distribution system the system neutral shall be connected to earth at all times without the use of contactors.

f) Combined PE (protective earth) and N (system earth) is allowed between transformer /generator and Nbusbar in first switchboard where the transformer secondary side/generator is terminated i.e. TN-C-Ssystem.

There shall be no connection between the N- and PE-conductor after the PEN-conductor is separated.

g) In case of earth fault in high voltage systems with earthed neutral, the current shall not be greater than full load current of the largest generator on the switchboard or relevant switchboard section and not less than three times the minimum current required to operate any device against earth fault. Electrical equipment in directly earthed neutral or other neutral earthed systems shall withstand the current due to single phase fault against earth for the time necessary to trip the protection device. It shall be assured that at least one source neutral to ground connection is available whenever the system is in the energised mode. For divided systems, connection of the neutral to the earth shall be provided for each section.

(IACS UR E11, 2.1.5 and 2.1.2)

h) For earthing of aluminium superstructures on steel vessels see 9.7.

1.1.4 Types of distribution systems

a) AC power: The following distribution systems can be used (for exemptions see 1.1.5):

- three-phase three-wire with high-resistance earthed neutral
- three-phase three-wire with low-resistance earthed neutral
- three-phase three-wire with directly earthed neutral
- three-phase three-wire with insulated neutral.

b) In addition for all voltages up to and including 500 V AC:

- three-phase four-wire with neutral earthed, but without hull return
- single-phase two-wire with insulated neutral
- single-phase two-wire with one phase earthed at the power source, but without hull return.

c) DC power: The following distribution systems can be used (for exemptions see 1.1.5):

- two-wire insulated
- two-wire with one pole earthed at the power source (without hull return)
- single-wire with hull return as accepted in 1.1.5.

1.1.5 Hull return systems

a) The hull return system of distribution shall not be used, except as stated in b) and c). (Interpretation of SOLAS Ch. II-1/45.3.1)

b) Provided that any possible resulting current does not flow directly through any gas hazardous spaces, the requirements of a) does not preclude the use of:

- impressed current cathodic protective systems
- limited and locally earthed systems
- insulation level monitoring devices provided the circulation current does not exceed 30 mA under the most unfavourable conditions
- intrinsically safe circuits.

(Interpretation of SOLAS Ch. II-1/45.3.2)

c) Where the hull return system is used for distribution of DC power, one of the busbars of the distribution board shall be connected to the hull. Outgoing final sub circuits i.e. all circuits fitted after the last protective device shall be with insulated two-wires or two-core cables. (Interpretation of SOLAS Ch. II-1/45.3.3)

1.1.6 Special requirements for non-metallic craft

a) All metal parts of a non-metallic craft shall be bonded together, in so far as possible in consideration of galvanic corrosion between dissimilar metals, to form a continuous electrical system, suitable for the earth return of electrical equipment and to connect the craft to the water when water-born. The bonding of isolated components inside the structure is not generally necessary, except in fuel tanks.

b) Each pressure refuelling point shall be provided with a means of bonding the fuelling equipment to the craft.

c) Metallic pipes capable of generating electrostatic discharges, due to the flow of liquids and gases shall be bonded so they are electrically continuous throughout their length and shall be adequately earthed.

d) Secondary conductors provided for the equalisation of static discharges, bonding of equipment, etc., but not for carrying lightning discharges shall have a minimum cross section of 5 mm^2 copper or equivalent surge current carrying capacity in aluminium.

e) The electrical resistance between bonded objects and the basic structure shall not exceed 0.02 Ohm except where it can be demonstrated that a higher resistance will not cause a hazard. The bonding path shall have sufficient cross-sectional area to carry the maximum current likely to be imposed on it without excessive voltage drop.

f) A main earth bar shall be defined and fitted at a convenient place on board. This earth bar shall be connected to a copper plate with a minimum area of 0.25 m2 attached to the hull and so located that it is immersed under all conditions of heel.

1.2 System voltages and frequency

1.2.1 General

a) Electric distribution systems shall operate within the voltage and frequencies given in 1.2.2 to 1.2.7. This also applies to distribution systems where one or more generator prime movers are driving other equipment.

When the main propulsion engine is used as a generator prime mover, variations caused by the wave motion or sudden manoeuvres including crash stop, shall not exceed the given limitations.

b) Voltage variations deviating from the standard values are accepted in systems if these are intentionally designed for the actual variations.

c) All voltages mentioned are root mean square values unless otherwise stated.

1.2.2 Maximum system voltages

a) Except as stated in b) and c), the following maximum voltages in distribution systems apply:

- connected by permanent wiring: 15000 V
- for portable appliances, which are not hand-held during operation, and with connection by flexible cable and socket outlet: 1000 V
- supply for lighting (including signal lamps), space heaters in accommodation spaces, socket outlets, and hand-held portable appliances and for control, communication and instrumentation equipment: 250 V. Phase voltage of a system with neutral earthed may be used for this purpose.

b) For High Speed, Light Craft and Naval Surface Craft, the maximum distribution voltage is limited to 500 V, except for crafts with electric propulsion systems, where higher voltages are accepted.

c) Where necessary for special application, higher voltages may be accepted by the Society.

(IACS UR E11 1.2)

1.2.3 Maximum control voltages

For control equipment being a part of power and heating installations (e.g. pressure or temperature switches for start and stop of motors), the maximum voltage is 1000 V. However, control voltage to external equipment shall not exceed 500 V.

1.2.4 Supply voltage variations

a) Electric AC distribution systems shall be designed and installed so that the voltage variations on main switchboards are maintained within these limits:

Steady state:	± 2.5% of nominal AC system voltage
Transient state:	from -15% to +20% of nominal AC voltage.

b) Electric DC battery powered systems shall be designed and installed so that the voltage variations on the main distribution board are maintained within these limits:

Voltage tolerance:	-15% to +30% of nominal DC system voltage
Voltage cyclic variation:	max 5%
Voltage ripple:	max 10%.

c) The requirement for maximum transient voltage shall also be complied with in case of load shedding or tripping of consumers. The requirement for maximum transient voltage is not applicable to failure conditions.

d) After a transient condition has been initiated, the voltage in a main distribution AC system shall not differ from nominal system voltage by more than ±3% within 1.5 s. In an emergency distribution system the voltage shall not differ from nominal system voltage by more than ±4% within 5 s.

e) In AC installations designed for variable system voltage, equipment and its protection devices shall be rated to operate within the design limits throughout the voltage range.

1.2.5 Voltage drop in the distribution system

a) An AC distribution system shall be designed and installed so that the stationary voltage drop in supply to individual consumers, measured from the main switchboard to the consumer terminals, does not exceed 6% of system nominal voltage.

b) A DC distribution system shall be designed and installed so that the stationary voltage drop in supply to individual consumers, measured from the battery distribution to the consumer terminals, does not exceed 10% of system nominal voltage.

c) Specific requirements for transient voltages on consumer terminals during start or stop are not given.

However, the system shall be designed so that all consumers function satisfactorily.

1.2.6 System frequency

a) The frequency variations in AC installations with fixed nominal frequency shall be kept within the following limits:

- 95 to 105% of rated frequency under steady load conditions
- 90 to 110% of rated frequency under transient load conditions.

b) In AC installations designed for variable system frequency, equipment and its protection devices shall be rated to operate within the design limits throughout the frequency range.

1.2.7 Harmonic distortion

a) Equipment producing transient voltage, frequency and current variations shall not cause malfunction of other equipment on board, neither by conduction, induction or radiation.

b) In distribution systems the acceptance limits for voltage harmonic distortion shall correspond to IEC 61000-2-4 Class 2. (IEC 61000-2-4 Class 2 implies that the total voltage harmonic distortion shall not exceed 8%.) In addition, no single order harmonic shall exceed 5%.

c) The total harmonic distortion may exceed the values given in b) under the condition that all consumers and distribution equipment subjected to the increased distortion level have been designed to withstand the actual levels. The system and components ability to withstand the actual levels shall be documented.

d) When filters are used for limitation of harmonic distortion, special precautions shall be taken so that load shedding or tripping of consumers, or phase back of converters, do not cause transient voltages in the system in excess of the requirements in 1.2.4. The generators shall operate within their design limits also with capacitive loading. The distribution system shall operate within its design limits, also when parts of the filters are tripped, or when the configuration of the system changes.

The following effects should be considered when designing for higher harmonic distortion in c):

- additional heat losses in machines, transformers, coils of switchgear and control gear
- additional heat losses in capacitors for example in compensated fluorescent lighting
- resonance effects in the network
- functioning of instruments and control systems subjected to the distortion
- distortion of the accuracy of measuring instruments and protective gear (relays)
- interference of electronic equipment of all kinds, for example regulators, communication and control systems, position- finding systems, radar and navigation systems.

A declaration or guarantee from system responsible may be an acceptable level of documentation.

2 Main Electric Power Supply System

2.1 General

2.1.1 Capacity

a) The main power supply system shall have the capacity to supply power to all services necessary for maintaining the ship in normal operation without recourse to the emergency source of power. (Interpretation of SOLAS Ch. II-1/40.1.1)

b) There shall be component redundancy for main sources of power, transformers and power converters in the main power supply system so that with any source, transformer or power converter out of operation, the power supply system shall be capable of supplying power to the following services:

- those services necessary to provide normal operational conditions for propulsion and safety
- starting the largest essential or important electric motor on board, except auxiliary thrusters, without the transient voltage and frequency variations exceeding the limits specified in 1.2
- ensuring minimum comfortable conditions of habitability which shall include at least adequate services for cooking, heating, domestic refrigeration (except refrigerators for air conditioning), mechanical ventilation, sanitary and fresh water
- for a duplicated essential or important auxiliary, one being supplied non-electrically and the other electrically (e.g. lubricating oil pump No. 1 driven by the main engine, No. 2 by electric motor), it is not expected that the electrically driven auxiliary is used when one generator is out of service
- For dead ship recovery, see 2.2.4.

(Interpretation of SOLAS Ch. II-1/41.1)

Those services necessary to provide normal operational conditions of propulsion and safety do not normally include services such as:

- thrusters not forming part of the main propulsion or steering
- mooring
- cargo handling gear
- refrigerators for air conditioning.

However, additional services required by a class notation will be added to the list of important services.

In regard to non-important load, the capacity of all generators can be taken into consideration.

2.1.2 Generator prime movers

a) Each generator required according to 2.1.1 shall normally be driven by a separate prime mover. Each generator shall be driven by one engine, and one engine shall only drive one generator.

b) If a prime mover for a generator is also used for driving other auxiliary machinery in such a way that it is physically possible to overload the engine, an interlock or other effective means for preventing such overloading shall be arranged. The availability of the generator shall be at least as for separately driven generators.

c) When generators driven by reciprocating steam engines or steam turbines are used, and the operation of the boiler(s) depends on electric power supply, there shall be at least one generator driven by an auxiliary diesel engine or gas turbine on board, enabling the boiler plant to be started.

d) A generator driven by a main propulsion unit (shaft generator) which is intended to operate at constant speed, e.g. a system where vessel speed is controlled only by varying propeller pitch, may be one of the required generators according to 2.1.1. There shall be at least one generator driven by a separate prime mover. The capacity of separately driven generators shall be sufficient to supply all essential and important services that can be expected to be simultaneously in use, regardless of the operational mode of the vessel, including stopped. This shall be possible without utilising any emergency power source. (Interpretation of SOLAS Ch. II-1/41.1.3)

e) Shaft generator installations which do not comply with the requirement given in d), may be fitted as additional source(s) of power provided that:

- on loss of the shaft generator(s) or upon frequency variations exceeding ±10%, a standby generating set is started automatically
- the capacity of the standby set is sufficient for the loads necessary for propulsion and safety of the vessel.

f) Generator prime movers shall comply with the requirements in Ch.1 Sec.2.

Shaft generators and other generators based on variable speed drives will be evaluated in each case. As a minimum, the following should be evaluated:

- availability
- stability of output voltage and frequency
- short circuit capability and protection.

2.2 System functionality

2.2.1 Start of generator sets

At least two generator sets, connected to separate main busbar sections, shall be arranged with systems for starting in a blackout situation. However, only one standby generator may be permitted if this generator is not intended to be used for normal operation of the ship.

2.2.2 Energy for starting

a) The energy used for starting in a blackout situation shall be arranged as required in 4.1.

b) Control power supply to electronic governors, AVRs and necessary control power for auxiliary engines shall, if dependent on external power, be arranged as required for starting arrangement in 4.

c) Where prime movers and/or generators arranged as standby generators depend upon auxiliary machinery systems being available in a blackout situation, these auxiliaries shall be arranged with at least two independent sources of power. At least one of the sources of power shall be from stored energy located within the machinery space. The capacity of the power sources shall correspond to the required number of starting attempts and/or last for at least 30 minutes.

d) Where prime movers and/or generators arranged as standby generators depend upon auxiliary machinery systems during standby mode in order to start in a blackout situation, auxiliaries for at least one generator shall be supplied from the main switchboard in order to comply with 1.1.1 c).

e) When a single, dedicated, standby generator is used, this generator set alone shall be arranged in accordance with this paragraph, i.e. two sources of energy for starting, control power and auxiliaries. As above, one of the sources for auxiliaries shall be from stored energy located within the machinery space.

Example of auxiliary system that must be available in a blackout situation may be fuel oil booster pump, and lubrication oil pump if start blocking is activated within 30 minutes after blackout.

Example of auxiliary system that must be supplied in standby mode may be pre lubrication pump and jacket water heating.

2.2.3 Load shedding and automatic restoration of power

Where electrical power is necessary for propulsion and steering of the ship, the system shall be so arranged that the electrical supply to equipment necessary for propulsion and steering, and to ensure safety of the vessel, will be maintained or immediately restored in case of loss of any one of the generators in service.

This means:

- The power system shall be equipped with automatic load shedding or other automatic means to prevent sustained overload of any generator, ref. 7.1.1
- Where the electrical power is normally supplied by one generator provision shall be made, upon loss of power, for automatic starting and connecting to

the main switchboard of standby generator(s) of sufficient capacity with automatic restarting of the essential auxiliaries, in sequential operation if required. Starting and connection to the main switchboard of the standby generator is to be preferably within 30 seconds, but in any case not more than 45 seconds, after loss of power.

- Where prime movers with longer starting time are used, this starting and connection time may be exceeded upon approval from the society.
- Where more than one generating set is necessary to cover normal loads at sea, the power supply system shall be provided with suitable means for tripping or load reduction of consumers. If necessary, important consumers may be tripped in order to permit propulsion and steering and to ensure safety. If the remaining on line generators are not able to permit propulsion and steering and to ensure safety, provision shall be made for automatic starting and connection to the main switchboard of the standby generator.

(Interpretation of SOLAS Ch.II-1/41.5.1.1)

2.2.4 Start from dead ship

a) The requirement for start from dead ship is given in Ch.1, Sec.1.

b) In addition, the generating sets shall be such as to ensure that with any one generator, transformer or power converter out of service, the remaining generating sets, transformers and power converters shall be capable of providing the electrical services necessary to start the main propulsion plant from a dead ship condition.

The emergency source of electrical power may be used for the purpose of starting from a dead ship condition if its capability either alone or combined with that of any other source of electrical power is sufficient to provide at the same time those services required to be supplied by 3.1.3, except fire pumps and steering gear, if any.

On installations without a dedicated emergency generator in accordance with 3.1.4, only one engine room is considered to be in dead ship conditions, since there should be redundancy in starting arrangement for each engine room as required for emergency generator sets. However, necessary energy for auxiliaries needed for start (fuel, lubrication oil priming, etc.) must have the same arrangement as the source for starting energy.

For vessels with two or more independent engine rooms but not complying with 3.1.4, the requirements for dead ship starting still applies, i.e. dead ship condition in both/all engine rooms simultaneously. Necessary energy for auxiliaries needed for start (fuel, lubrication oil priming, etc.) must have the same arrangement as the source for starting energy In cases where only electric starting is arranged for engines driving generators and the main propulsion engines, an additional battery for “dead ship” starting may be installed. This battery shall then be dedicated for this purpose and always kept fully charged and monitored.

3 Emergency Power Supply System

3.1 General

3.1.1 Emergency power source

a) The emergency source of power, associated transforming equipment, emergency switchboard, emergency lighting switchboard and transitional source of emergency power shall be located above the uppermost continuous deck and be readily accessible from open deck. It shall not be located forward of the collision bulkhead. (Interpretation of SOLAS Ch. II-1/43.1.2).

b) The emergency source of electrical power may be either a generator or an accumulator battery. (Interpretation of SOLAS Ch. II-1/43.3).

c) The emergency source of power shall be automatically connected to the emergency switchboard in case of failure of the main source of electric power. If the power source is a generator, it shall be automatically started and within 45 s supply at least the services required to be supplied by transitional power as listed in Table 3.1. (Interpretation of SOLAS Ch. II-1/43.3.1.2, 43.3.2.2 and 43.3.2.3).

d) If the emergency source of power is not automatically connected to the emergency switchboard, a transitional source of emergency electrical power, suitably located for use in an emergency, with sufficient capacity of supplying the consumers listed in Table 3.1, may be accepted. (Interpretation of SOLAS Ch. II- 1/43.3.1.3).

e) The emergency source of power shall not be used for supplying power during normal operation of the vessel. Exceptionally, and for short periods, the emergency source of power may be used for blackout situations, starting from dead ship, short term parallel operation with the main source of electrical power for the purpose of load transfer and for routine testing of the emergency source of power. (Interpretation of SOLAS Reg. II-1/43.3.1.3).

Exception for high speed light craft:

For a craft applying the HSC Code, location of emergency supply system below uppermost continuous deck may be accepted provided easy access from a normally manned area. However, the emergency source of power shall always be located above worst damage waterline.

Exception for ships:

The requirement for emergency source of power applies to all cargo vessels with the following exemptions:

- ships of less than 500 gross tonnage
- fishing vessels less than 24 m.
- ships with service restrictions will be considered on a case by case basis

For the requirements for an emergency generator, see 3.3.

For the requirements for a transitional source of emergency electrical power, see 3.2.

3.1.2 Capacity

a) The electrical power available shall be sufficient to supply all services essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously, also taking into account starting currents and transitory nature of certain loads. (Interpretation of SOLAS Ch. II-1/43.2)

b) Where the emergency source of electrical power is an accumulator battery it shall be capable of carrying the emergency electrical load without recharging while maintaining the voltage of the battery as required by 1.2. (Interpretation of SOLAS Ch. II-1/43.3.2.1)

c) When non-emergency consumers are supplied by the emergency source of power, it shall either be possible to supply all consumers simultaneously, or automatic disconnection of non-emergency consumers upon start of the generator shall be arranged. The system shall be so arranged that the largest consumer connected to the emergency power supply system can be started at all times without overloading the generator unless automatically disconnected upon start of the emergency generator. (Interpretation of SOLAS Ch. II-1/ 43.5.5)

d) Starting air compressors, preheaters and lubrication oil pumps for the main engine or auxiliary engines may be equipped for automatic disconnection from the emergency switchboard. Such consumers necessary for starting from dead ship, if supplied from the emergency source of power, shall be possible to connect manually at the emergency switchboard also when the emergency generator is running. If they may cause overloading of the emergency generator, warning signs shall be fitted also stating the load of the consumers.

The emergency generator rating shall be based upon the consumed power for all consumers that may be in simultaneous operation. Non-emergency motors, which will not automatically start, are considered to be automatically disconnected.

3.1.3 Services to be supplied

a) For High Speed, Light Craft and Naval Surface Craft see appropriate rules.

b) For additional class notations, additional requirements may apply.

c) For main class ships the list of services in Table 3.1 shall be supplied by an emergency source of power and by a transitional source of power, if any, for the period listed.

d) In a ship engaged regularly in voyages of short duration, a lesser period than the 18 hour period specified in Table 3.1 is accepted, but not less than 12 hours. (Interpretation of SOLAS Ch. II-1/43.2.6.2)

e) The emergency source of electrical power shall be capable of supplying simultaneously at least the services listed in Table 3.1 for the periods specified, if they depend upon an electrical source for their operation. (Interpretation of SOLAS Ch. II-1/43.2.1 to 43.2.6.1)

f) For fishing vessels the following services shall be supplied for a period of 3 hours for vessels below 45 m and 8 hours for vessels of 45 m and above:

- VHF radio installation required by Torremolinos Convention reg. IX/6(1)(a) and (b)
- Internal communication equipment
- Fire detecting system
- Signals which may be required in an emergency
- Navigation lights if solely electrical
- Emergency lighting:
- of launching stations and over side of the vessel
- in all alleyways, stairways and exits
- in spaces containing machinery or the emergency source of power
- in control station
- in fish handling and fish processing space
- Electrical driven emergency fire pump if any.

If applicable:

- The MF radio installation required by Torremolinos Convention IX/8(1)(a) and (b) and reg. IX/9(1)(b) and (c)
- The ship earth station required by Torremolinos Convention regulation IX/9(1)(a)
- MF/HF radio installation required by Torremolinos Convention IX/9(2)(a) and (b) and reg. IX/10(1).

Table 3.1: Services to be supplied by an emergency source and by a transitional source, including required duration for main class

Service	Emergency power consumers in ships	Duration of emergency power (h)	Duration of transitional power [4] (h)
Emergency lighting	At every muster and embarkation station, for survival craft and their launching appliances, and at the area of water into which it shall be launched.	3	0.5 [2]
	In all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks.	18	0.5 [2]
	In the machinery spaces and main generating stations including their control positions.	18	0.5 [2]
	In all control stations, machinery control rooms, steering gear and at each main and emergency switchboard.	18	0.5 [2]
	At all stowage positions for firemen's outfits.	18	0.5 [2]
	At the fire pump referred to in this table and its starting position.	18	0.5 [2]
	At the sprinkler pump and its starting position, if any.	18	0.5 [2]
	At the emergency bilge pump and its starting position, if any.	18	0.5 [2]
	In all cargo pump-rooms of tankers	18	0.5 [2]
Navigation lights	The navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force.	18	0.5 [2]
Fire pumps	One of the fire pumps required by SOLAS Ch. II-10.2.2 (Ch, 1, Sec.11) if dependent upon the emergency generator for its source of power. (SOLAS Ch. II-1/43.2.5)	18	
Steering gear	The steering gear if required to be so supplied by Ch.1, Sec.12. (SOLAS Ch. II-1/43.2.6.1) (For a ship of less than 10000 gross tonnage the duration shall be at least 10 minutes.)	0.5	
Watertight doors and hatches	The power, control and indicators for watertight doors and hatches.	18	0.5 [2]
Life boat	Second means of launching of free fall life boat, ref. LSA Code.	6)	
Stabilizers (if any)	Means to bring the stabilizer wings inboard and indicators on the navigating bridge to show the position of the stabilizer wings if there is a danger of the survival craft being damaged by the ship's stabilizer wings		
Communication [3]	The VHF radio installation required by SOLAS Ch. IV/7.1.1 and IV/7.1.2.	18	
	If applicable: — the MF radio installation required by SOLAS Ch.s IV/ 9.1.1, IV/9.1.2, IV/10.1.2 and IV/10.1.3 — the ship earth station required by regulation IV/10.1.1 — the MF/HF radio installation required by regulations IV/ 10.2.1, IV/10.2.2, IV/10.1.2 and IV/11.1	18	
	All internal communication equipment, as required, in an emergency; shall include: — means of communication between the navigating bridge and the steering gear compartment — means of communication between the navigating bridge and the position in the machinery space or control room from which the engines are normally controlled — means of communication between the bridge and the positions fitted with facilities for operation of radio equipment.	18 [1]	0.5 [2]
	Intermittent operation of the daylight signaling lamp, the ship's whistle, the manually operated call points, and all internal signals that are required in an emergency.	18 [1]	0.5 [2]
Alarm systems [5]	The fire detection and alarm systems.	18 [1]	0.5 [2]
	The gas detection and alarm systems	18 [1]	0.5 [2]
	The general alarm system.	18 [1]	0.5 [2]

1) Unless such services have an independent supply for the period of 18 hours from an accumulator battery suitably located for use in an emergency.

2) Unless such equipment has an automatically charged battery with adequate capacity, suitably located for use in an emergency.

3) Means of communication according to relevant SOLAS requirements and ACS Statutory Interpretations apply for mandatory internal communications systems.

4) A transitional source of power is required for:

- vessels where the emergency source of power is not automatically connected to the emergency switchboard within 45 s
- class notation Passenger Ship.

5) Only when the service or function is required by other applicable rules.

6) Power for launching of the life boat shall be available on demand with duration of 10 minutes for each lifeboat.

3.1.4 Independent installation of power sources

If the applicable regulation for the vessel is the IMO HSC Code, or when alternative emergency power arrangement has been accepted by the authorities of the flag state the following may apply:

Where the main source of electrical power is located in two or more spaces which have their own systems, including power distribution and control systems, completely independent of the systems in the other spaces and such that a fire or other casualty in any one space will not affect the power distribution from the others, or to the services in Table 3.1, the requirements for self-contained emergency power source may be considered satisfied without an additional emergency source of electrical power, provided that:

- There are at least two generator sets meeting the inclination design requirements for emergency installations in Sec.3, 2.1.1
- Each set has capacity to meet the requirements in item 3.1.2
- These generator sets are located in each of at least two spaces
- A casualty in any one space will not affect the control system for automatic start and connection of both/ all these generator sets.
- Power to all required emergency functions, as listed in Table 3.1, supplied from main switchboards and sub distributions are to be automatically available within 45 seconds when power is automatically restored after a black-out
- Load shedding/trip is arranged to prevent overload of these generator sets
- Transitional source of power is installed when required in 3.2.1
- The location of each of the spaces referred to in this paragraph is such that one of these generator sets remains operable and readily accessible in the final condition of damage. Further, the boundaries shall meet the provisions of 9.1.2, except that contiguous boundaries shall consist of an A-60 bulkhead and a cofferdam or a steel bulkhead insulated to class A-60 on both sides

- Bus tie breakers between the spaces have short circuit protection providing discrimination
- The arrangements of these generating sets comply with the requirements given in:
- 3.1.5 c), i.e. bus-tie breakers shall open automatically upon blackout
- 3.1.5 h)
- 3.3.1
- 3.3.3 (see guidance note).

The second source of energy for starting may be located outside the machinery space. In case of a fire or other casualty in any one space a total of at least two sources of starting energy for the remaining generator(s) have to be available.

The system philosophy for the electrical power supply system should describe how this paragraph is complied with.

In addition operating philosophy, it should include description of physical location of main components and cable routings. The test program for onboard testing should describe in detail how this functionality shall be tested.

A vessel built in accordance with this paragraph will not have any dedicated emergency power system, since the two (or more) independent main power systems are considered to ensure power supply to emergency consumers at all times. Compliance with 3.3.2 is not required.

3.1.5 Emergency switchboard

a) The emergency switchboard shall be installed as near as is practicable to the emergency source of electrical power. (Interpretation of SOLAS Ch. II-1/43.5.1)

b) Where the emergency source of electrical power is a generator, the emergency switchboard shall be located in the same space unless the operation of the emergency switchboard would thereby be impaired. (Interpretation of SOLAS Ch. II-1/43.5.2)

c) In normal operation, the emergency switchboard shall be supplied from the main switchboard by an interconnecting feeder. This feeder shall be protected against overload and short circuit at the main switchboard, and shall be disconnected automatically at the emergency switchboard upon failure of the supply from the main source of electrical power. (Interpretation of SOLAS Ch. II-1/43.5.4)

d) Where the emergency switchboard is arranged for the supply of power back to the main distribution system, the interconnecting cable shall, at the emergency switchboard end, be equipped with switchgear suitable for at least short circuit protection.

e) The emergency switchboard and emergency distribution boards shall not be considered as part of the main distribution system, even though supplied from such during normal operation.

f) Technical requirements for functionality and construction for main switchboards, apply to emergency switchboards.

g) Provision shall be made for the periodic testing of the complete emergency system and shall include the testing of automatic starting arrangements. (Interpretation of SOLAS Ch. II-1/43.7)

h) No accumulator batteries, except the starting battery for the emergency generator prime mover and control and monitoring for the emergency system, shall be installed in the same space as the emergency switchboard. (Interpretation of SOLAS Ch. II-1/43.5.3)

i) Cables between equipment installed in the emergency generator room, shall be run inside the boundary of the room.

3.2 Transitional source

3.2.1 Transitional source of emergency electrical power

a) A transitional source of power is required where the emergency source of power is not arranged for automatic connection to the emergency switchboard within 45 s, or if required by other applicable rules, e.g. class notation Passenger Ship.

b) The transitional source of electrical power shall consist of an accumulator battery suitably located for use in an emergency as required for emergency power in 3.1.1, unless it supplies power to consumers within the same space as the transitional source itself.

c) The battery source shall be charged by the emergency power distribution system and be able to operate, without recharging, while maintaining the voltage of the battery throughout the discharge period as required by 3.1.2. The battery capacity shall be sufficient to supply automatically, in case of failure of either the main or the emergency source of electrical power, for the duration specified, at least the services required by Table 3.1, if they depend upon an electrical source for their operation. See notes to Table 3.1. (Interpretation of SOLAS Ch. II-1/43.4)

3.3 Emergency generators

3.3.1 Prime mover for emergency generator

a) Where the emergency source of electrical power is a generator, it shall be driven by a suitable prime mover having independent supply of fuel with a flashpoint (closed cup) of not less than 43oC and shall have auxiliary systems e.g. cooling system, ventilation and lubrication operating independently of the main electrical power system. (Interpretation of SOLAS Ch. II-1/43.3.1.1)

b) The prime mover shall be started automatically upon failure of the main source of electrical power supply. (Interpretation of SOLAS Ch. II-1/43.3.1.2)

c) Where automatic start of the emergency generator is required and the emergency source of power is not ready for immediate starting, an indication shall be given in the engine control room.

3.3.2 Protective functions of emergency generating sets

a) The protective shutdown functions associated with emergency generating sets shall be limited to those necessary to prevent immediate machinery breakdowns i.e. short circuit.

b) Other protective functions such as overcurrent, high temperature etc. shall, if installed, give alarm only. It is recommended that such alarms are given to the main alarm system.

If overcurrent protection release is integrated in the circuit breaker, the setting of this release shall be set at its maximum value.

c) For use as a harbour generator, see 3.3.4.

3.3.3 Starting arrangements for emergency generating sets

a) An emergency generating set shall be capable of being readily started in its cold condition at a temperature of 0ºC. If this is impracticable, or the vessel is intended for operation at lower ambient temperatures, provisions shall be made for heating arrangements to ensure ready starting of the generating sets. (Interpretation of SOLAS Ch. II-1/44.1)

b) Emergency generating set shall be equipped with starting device with a stored energy capability of at least three consecutive starts. A second source of energy shall be provided for an additional three starts within 30 minutes, unless manual starting can be demonstrated to be effective within this time. One starting motor is sufficient. The duration of each starting attempt shall be minimum 10 s. (Interpretation of SOLAS Ch. II-1/44.2)

c) Stored energy for starting shall be maintained at all times, and shall be powered from the emergency switchboard. All starting, charging and energy storing devices shall be located in the emergency generator space. Compressed air starting systems may however be maintained by the main or auxiliary compressed air system through a suitable non-return valve fitted in the emergency generator space. (Interpretation of SOLAS Ch. II-1/44.3)

d) If accumulator batteries are used for starting of the emergency generator prime mover, every such prime mover shall have separate batteries that are not used for any purpose other than the operation of the emergency generating set.

e) If the emergency generator set is equipped with an electronic governor, electronic AVR, priming pumps or other auxiliaries dependent upon electric power supply for a successful start, power supply to this equipment shall be in accordance with the requirements for energy for starting of emergency generating sets.

3.3.4 Emergency generator used in port

a) The emergency source of power may be used during time in port for the supply of the ship mains, provided the requirements for available emergency power is adhered to at all times.

b) To prevent the generator or its prime mover from becoming overloaded when used in port, arrangements shall be provided to shed sufficient non-emergency loads to ensure its continued safe operation.

c) The prime mover shall be arranged with fuel oil filters and lubrication oil filters, monitoring equipment and protection devices as required for the prime mover for main power generation and for unattended operation.

d) The fuel oil supply tank to the prime mover shall be provided with a low level alarm, arranged at a level ensuring sufficient fuel oil capacity for the emergency services for the required period.

e) Fire detectors shall be installed in the location where the emergency generator set and emergency switchboard are installed.

f) Means shall be provided to readily change over to emergency operation.

g) Control, monitoring and supply circuits, for the purpose of the use of the emergency generator in port shall be so arranged and protected that any electrical fault will not influence the operation of the main and emergency services. When necessary for safe operation, the emergency switchboard shall be fitted with switches to isolate the circuits.

h) Instructions shall be provided on board to ensure that when the vessel is under way all control devices (e.g.valves, switches) are in a correct position for the independent emergency operation of the emergency generator set and emergency switchboard. These instructions are also to contain information on required fuel oil tank level, position of harbour or sea mode switch if fitted, ventilation openings etc.

4 Battery Systems

4.1 General

4.1.1 Capacity of accumulator batteries

Batteries that shall be used for power supply required by these rules shall be dimensioned for the time required for the intended function at an ambient temperature of 0°C, unless heating is provided.

4.1.2 Battery powered systems

a) Each battery powered system shall have a separate charging device, suitable for the actual service. This may alternatively be:

- a charging device supplied from the vessel's primary or secondary electric distribution. Such charging devices are considered as important consumers
- a charging dynamo driven by one of the engines which the battery normally supplies, except that this is not allowed for auxiliary engines for emergency generator and emergency fire pump.

b) Each battery required by these rules shall have its own dedicated charging device.

c) Each charging device is, at least, to have sufficient rating for recharging to 80% capacity within 10 hours, while the system has normal load.

d) The battery charger shall be suitable to keep the battery in full charged condition, (float charge), taking into account battery characteristics, temperature and load variations. If the battery requires special voltage regulation to obtain effective recharging, then this is to be automatic. If manual boost charge is provided, then the charger is to revert to normal charge automatically.

When the charging dynamo is an AC generator (alternator), particular attention should be paid to ensure that no damage would occur if the connection with the battery is broken. Provisions shall be made for preventing reverse current from the battery through the charging dynamo.

4.1.3 Battery monitoring

An alarm shall be given at a manned control station if the charging of a battery fails, alternatively an alarm shall be given if the battery is being discharged. Requirements for alarm if ventilation fails are given in 9.4.

A single common alarm signal to a central alarm system may be accepted for the two alarms listed in this paragraph.

If other alarms are included in the common alarm signal, it must be ensured that an active alarm will not prevent initiation of any new alarm with its audible and visual indication.

4.1.4 Battery arrangement

Battery installations shall comply with the requirements in 9.4.

5 Starting Arrangement for Engines with Electric Starter

5.1 General

5.1.1 Starting arrangements for main engines

a) When electric starting arrangement for main engines is used, there shall be at least two separately installed batteries, connected by separate electric circuits arranged such that parallel connection is not possible. Each battery shall be capable of starting the main engine when in cold and ready to start condition.

b) When two batteries are serving a single main engine, a change-over switch or link arrangement for alternative connection of the starter motor with its auxiliary circuits to the two batteries shall be provided.

c) Starting arrangements for two or more main engines shall be divided between the two batteries and connected by separate circuits. Arrangements for alternative connection of one battery to both (or all) engines can be made, if desired.

d) The batteries shall be installed in separate boxes or lockers or in a common battery room with separate shelves (not above each other).

e) Each battery shall have sufficient capacity for at least the following start attempts of the engines being normally supplied:

- 12 starts for each reversible engine
- 6 starts for each non-reversible engine connected to a reversible propeller or other devices enabling the engine to be started with no opposing torque.

The duration of each starting shall be taken as minimum 10 s. If the starting batteries are also used for supplying other consumers, the capacity shall be increased accordingly.

f) For multi-engine propulsion plants the capacity of the starting batteries shall be sufficient for 3 starts per engine. However, the total capacity shall not be less than 12 starts and need not exceed 18 starts.

5.1.2 Starting arrangement for auxiliary engines

a) Electric starting arrangement for a single auxiliary engine not for emergency use, shall have a separate battery, or it shall be possible to connect it by a separate circuit to one of the main engine batteries, when such are used according to 5.1.1.

b) When the starting arrangement serves two or more auxiliary engines, there shall at least be two separate batteries, as specified for main engines in 5.1.1. The main engine batteries, when such are used, can also be used for this purpose.

c) Each starting battery shall have sufficient capacity for at least three start attempts of each of the engines being normally supplied. The duration of each starting shall be taken as minimum 10 s. If the starting batteries are also used for supplying other consumers, the capacity shall be increased accordingly.

6 Electric Power Distribution

6.1 Distribution in general

6.1.1 General

a) All switchboards and outgoing circuits shall be provided with switchgear so that isolation for maintenance is possible. See Sec.4, 1.1.5.

b) Each essential or important consumer shall be connected to a main switchboard or distribution board by a separate circuit.

c) Two units supplied from the main generators and serving the same essential or important purpose shall have a separate supply circuit from different sections of the main switchboard(s) or shall be divided between at least two distribution switchboards, each having a separate supply circuit from different sections of the main switchboard(s). In instances where more than two units are used and the switchboard has only two sections, the circuits are to be evenly divided between the two sections.

d) When a component or system has two or more power supply circuits with automatic change over, an alarm shall be initiated upon loss of any of these power supplies.

e) For converters serving as AC power supply units used as emergency or transitional source of power, or as power supply to essential or important consumers, a manual electrically independent bypass arrangement shall be provided unless redundant supply to the consumers is otherwise ensured.

Equipment suitable for isolation is defined in IEC 60947-1 clause 7.1.7. Contactors are therefore normally not accepted as suitable for isolation.

6.1.2 Consequence of single failure

a) The failure of any single circuit or busbar section shall not endanger the services necessary for the vessel's manoeuvrability. The failure of any single circuit shall not cause important services to be out of action for long periods. Any single failure shall not render duplicated consumers serving essential or important services inoperable.

b) When the secondary distribution is arranged as two separate systems each fed from one transformer or converter, duplicated essential or important consumers shall be divided between the two systems.

c) Each transformer required according to 2.1.1 shall be installed as a separate unit, with a separate enclosure.

Single failure means failure in any single circuit, feeder, transformer or part of switchboard within one bus tie section.

6.1.3 Division of main busbars

a) Where the main source of electrical power is necessary for propulsion of the ship, and for high voltage distribution systems, the main busbar shall be subdivided into at least two parts which shall normally be connected by circuit breakers or other approved means; so far as is practicable, the connection of generating sets and other duplicated equipment shall be equally divided between the parts. (Interpretation of SOLAS Ch. II-1/41.5.1.1 and 41.5.1.3)

b) Where two separate switchboards are provided and interconnected with cables, a circuit breaker shall be provided at each end of the cable. See Sec.4, 2.1.6. (IACS UR E11 2.1.1)

Other approved means can be achieved by:

Circuit breaker without tripping mechanism; or disconnecting link or switch by which busbars can be split easily and safely. Bolted links, for example bolted busbar sections, are not to be accepted.

Single failure means failure in any single circuit, feeder, transformer or part of switchboard within one bus tie section.

Additional class notations may require that each part of the main busbars with its associated generators is arranged in separate compartments.

6.1.4 Generator circuits

a) Each generator shall be connected by a separate circuit to the corresponding switchboard.

b) When a generator is used for direct supply to single consumers, or can be connected to more than one busbar section, more than one generator breaker is acceptable. In such cases, additional requirements to protection of the circuits between the generator terminals and the generator circuit breakers are given in 7.3.1 f).

6.2 Lighting

6.2.1 Lighting system arrangement

The lighting system shall be based on the following separation of the system:

a) main lighting system supplied from the main power supply system

b) emergency lighting system supplied from the emergency power supply system

c) escape (transitional) lighting system supplied from a battery backup (transitional) source of electrical power (when required).

The main electric lighting system shall provide illumination throughout those parts of the ship normally accessible to, and used by, passengers or crew, and shall be supplied from the main source of electrical power. (Interpretation of SOLAS Ch. II-1/41.2.1)

The emergency lighting system shall provide illumination throughout those parts of the ship listed in Table 3.1, and shall be supplied from the emergency source of electrical power. Upon loss of main source of power, all required emergency lighting shall be automatically supplied from the emergency source of power. Emergency exterior lighting may however be controlled by switch on the bridge.

The escape (transitional) lighting system shall provide illumination throughout those parts of the unit listed in Table 3.1, supplied by integrated or centralized batteries. These batteries shall have supply from an emergency distribution system. The escape lighting system shall be switched on automatically in the event of failure of the main and emergency power supply system.

If the main lighting is arranged as two separate secondary systems, each fed from a separate transformer or converter, then the main lighting shall be divided between the two systems so that with one system out of operation, there remains sufficient lighting to carry out all functions necessary for the safe operation of the vessel.

Redundancy requirement for generators and transformers supplying the main lighting system is given in 2.1.1.

For vessels meeting the requirements in 3.1.4, i.e. which does not have a dedicated emergency source of power, c) does not apply. However, sufficient lighting to carry out all functions necessary for the safe operation of the vessel and in all areas where emergency light is required according to Table 3.1, shall be divided between at least two circuits from the independent power sources.

For vessels where emergency source of power is not required, b) does not apply. However, the following lighting shall be divided between at least two circuits from different parts of the main switchboard:

- engine room lighting
- switchboard room lighting
- lighting in control room and of control positions
- lighting in alleyways, stairways leading up to the boat deck and in saloons.

Requirements to arrangement of the two lighting systems are located in 9.1.2.

6.2.2 Navigation light controllers

The navigation lights shall be connected to a dedicated navigation light controller placed on the bridge or in the chart room or space. This navigation light controller shall not be used for other purposes, except that signal lights required by canal authorities can be supplied.

According to IMO MSC253 (83) navigation lights mean the following lights:

- masthead light, sidelights, stern light, towing light, all-round light, flashing light as defined in Rule 21 of COLREG

- all-round flashing yellow light required for air-cushion vessels by Rule 23 of COLREG; and
- manoeuvring light required by Rule 34(b) of COLREG.

6.2.3 Power supply to navigation lights

a) The navigation light controller shall be supplied by two alternative circuits, one from the main source of power and one from the emergency source of power. A changeover switch shall be arranged for the two supply circuits. Upon failure of either power supply, an alarm shall be given.

b) For vessels without emergency power the navigation lighting shall have a battery backed up supply.

6.2.4 Navigation light circuits

a) A separate circuit shall be arranged for each light connected to this controller with a multipole circuit breaker, multipole fused circuit breaker or with a multipole switch and fuses in each phase.

b) The overload and short circuit protection for each of these circuits shall be correlated with the supply circuit to ensure discriminative action of the protection devices.

c) Each light circuit shall be provided with an automatic monitoring device when the light circuit is switched on, giving alarm in the event of bulb failure, and in the event of a short circuit.

d) According to IMO MSC.253 (83) some of the navigation lights shall either be duplicated or have duplicated lamps. When duplication is required, each navigation light or lamp shall be fed by a separate circuit as required in this paragraph.

6.3 Power supply to control and monitoring systems

6.3.1 General

This part of the rules defines the principal requirements to power supply arrangement for control and monitoring systems. Where particular power supply requirements are valid it is specified in the applicable rules.

6.3.2 Power supply

The power supply shall in general be supplied from the same distribution board as the consumer or the system being served.

The general principle is that the power supply to the control and monitoring systems shall reflect the general segregation in the power supply arrangement to the consumers or equipment under control.

6.3.3 Independent power supplies

When independent power supplies are required, these supplies shall be from separate sections of the main switchboard or from distribution boards supplied from separate sections of the main switchboard.

For single control and monitoring systems where independent power supplies are required, an automatic change-over for the two power supplies shall be arranged as close as possible to the consumer.

Two supplies from a common power distribution board are not considered to be independent, even if the distribution board itself is fed from independent supplies.

Single control and monitoring systems in this category shall be equipped with two terminals for connection of the external power supply cables. The change-over arrangement shall then be located on the consumer side of these terminals.

6.3.4 Additional emergency supply

For control and monitoring systems where supply from both main and emergency source of power are required, but not requiring independent supplies, the power may be supplied by a single circuit from a power distribution board provided that this distribution board is supplied from both the main- and emergency distribution systems.

Such a distribution board shall be located in the same space as the system being served.

The emergency switchboards alone are not considered to comply with the above, even if supplied from main switchboard during normal operation.

6.3.5 Uninterruptible power supply (UPS)

For control and monitoring systems where both uninterruptable and independent power supplies are required, at least one of the supplies shall be provided with stored energy.

A UPS alone is not considered to provide the required independency, even if the UPS itself is fed by two independent supplies and equipped with static bypass. An electrically independent bypass is required.

6.3.6 Monitoring of power supplies

Upon failure of the power supply to essential and important functions, an alarm shall be initiated unless loss of function will otherwise be alarmed. In case of duplicated or independent power supplies, both supplies shall be monitored.

6.4 Low voltage shore connections

6.4.1 General

a) When supply from shore is used, the connection of the supply cable from shore shall generally be carried out by suitable terminals placed in a switchboard or in a shore-connection box with a permanent cable connection to a receiving switchboard. In the shore-connection box, switchgear and protection as required for feeder circuits shall be installed, except that overcurrent protection can be omitted if such protection is installed in the receiving switchboard.

b) In the receiving switchboard, the circuit shall, at least, be provided with a switch - disconnector.

c) If the shore connection is supplying power via the emergency switchboard, the following applies:

- 3.1.5 d) shall be complied with.
- Under-voltage disconnection of the power supply from shore shall be arranged so that the shore connection supply is disconnected upon loss of power in order to enable automatic start and connection of the emergency generator.

d) For AC systems with earthed neutral, terminals for connection between the shore and ship's neutrals shall be provided.

e) For circuits rated maximum 63 A, connection by socket outlet can be used instead of shore-connection box.

The circuit may then have short circuit and overcurrent protection in the receiving switchboard only.

National authorities may require changeover or interlocking system, so arranged that the connection to shore cannot be fed from the vessel's generators.

7 Protection

7.1 System protection

7.1.1 Overload protection

a) Load shedding or other equivalent automatic arrangements shall be provided to protect the generators, required by these rules, against sustained overload. (Interpretation of SOLAS Ch. II-1/41.5.1.2)

b) In power distribution systems that might operate in different system configurations, the load shedding shall be such arranged that necessary system protection is functioning in all system configurations.

c) A load shedding, or load reduction system, if installed, shall be activated at a load level suitable below 100% of the overload or overcurrent protection setting.

Overload protection may be arranged as load reduction or as the tripping of non-important consumers. Where more than one generator is necessary to cover normal load at sea, then important consumers may be tripped, if necessary.

7.1.2 Insulation fault

a) Each insulated, or high resistance earthed primary or secondary distribution system shall have a device or devices to continuously monitor the values of electrical insulation to earth and to give an audible or visual indication in case of abnormally low insulation values. For high voltage system the alarm shall be both audible and visual (IACS E11 2). However, audible or visual indication can be omitted provided automatic disconnection is arranged. The circulation current generated by each device for insulation monitoring shall not exceed 30 mA under the most unfavourable conditions. (Interpretation of SOLAS Ch. II-1/45.4.2)

b) The requirements in a) shall be applied on all galvanic isolated circuits, except for:

- dedicated systems for single consumers
- galvanic separated local systems kept within one enclosure.

c) On high voltage systems automatic disconnection shall be arranged for operation at 1/3 or less of the minimum earth fault current. However, for systems with high-resistance earthed neutral or isolated neutral, this disconnection can be replaced with an alarm when the distribution system and equipment are dimensioned for continuous operation with earth fault. For the requirements for voltage class of high voltage cables dependent of system behaviour with earth fault, see 10.1.3.

d) On systems with low-resistance earthed neutral automatic disconnection of circuits having insulation faults shall be arranged. This earth fault protection shall be selective against the feeding network. For low resistance earthed neutral systems the disconnection shall operate at less than 20% of minimum earth fault current.

e) Test lamps or similar without continuous monitoring is accepted for:

- battery systems not extending their circuits outside a single panel
- battery system for non-important systems below 50 V and
- battery systems serving one function only.

f) For direct-earthed system (TN) the three-phase overcurrent and short circuit protection is accepted as earth fault protection.

7.1.3 Overvoltage protection

Overvoltage protection shall be arranged for lower-voltage systems supplied through transformers from high voltage systems.

Direct earthing of the lower voltage system, or the use of voltage limitation devices, are considered as adequate protection. Alternatively, an earthed screen between the primary and secondary windings may be used. See Sec.3, 4.4 regarding current and voltage transformers.

7.1.4 Discrimination

All circuits in the electric distribution systems shall have protection against accidental overcurrents and short circuits as described in 7.2. The protective devices shall provide complete and co-ordinated protection through discriminative action in order to ensure:

- Continuity of supply to essential consumers and emergency consumers.
- Continuity of service to important consumers. Supply to healthy circuits shall be automatically reestablished.
- Elimination of the fault to reduce damage to the system and hazard of fire.

Continuity of supply is the condition for which during and after a fault in a circuit, the supply to the healthy circuits is permanently ensured.

Continuity of service is the condition for which after a fault in a circuit has been cleared, the supply to the healthy circuits is re-established.

7.2 Circuit protection

7.2.1 General

a) Each separate circuit shall be protected against short circuit with the protection in the feeding end.

b) Each consumer shall be protected against overcurrent.

c) All consumers shall be separately protected.

d) Loss of control voltage to protective functions shall either trip the corresponding equipment or give an alarm on a manned control position, unless other specific requirements apply.

e) No fuse, switch or breaker shall be inserted in earthing connections or conductors. Earthed neutrals may be disconnected provided the circuit is disconnected at the same time by means of multipole switch or breaker.

f) The circuit breaker control shall be such that “pumping” (i.e. automatically repeated breaking and making) cannot occur.

g) Circuits for heating cables, tapes, pads, etc. should be equipped with earth fault breakers. See Sec.10, 3.10.

Exceptions:

- For special requirements for protection of steering gear circuits.
- For emergency generator see 3.3.2.
- Circuit supplying multiple socket outlets, multiple lighting fittings or other multiple non-important consumers is accepted when rated maximum 16 A in 230 V systems, or 30 A in 110 V systems.
- Non-important motors rated less than 1 kW, and other non-important consumers, rated less than 16A, do not need separate protection.
- Separate short circuit protection may be omitted for consumers serving non-important services. Each motor shall have separate overcurrent protection and controlgear.
- Separate short circuit protection may be omitted at the battery or busbar end of short circuit proof installed cables.

7.2.2 Capacity

a) The breaking capacity of every protective device shall be not less than the maximum prospective short circuit at the point where the protective device is installed.

b) The making capacity of every circuit breaker or switch intended to be capable of being closed, if necessary, on short circuit, shall not be less than the maximum value of the prospective short circuit current at the point of installation.

c) For non-important circuits, circuit breakers with insufficient breaking capacity can be used, provided that they are co-ordinated by upstream fuses, or by a common upstream circuit breaker or fuses with sufficient breaking capacity protecting the circuit breaker and connected equipment from damage.

d) Circuit breakers in main switchboards are generally to be selected according to their rated service short circuit breaking capacity. (ICS according to IEC 60947-2 Clause 4)

e) If the main switchboard is divided by a switch disconnector (IEC 60947-3) or a circuit breaker (IEC 60947- 2) the feeder breakers in the main switchboard may be selected according to their rated ultimate breaking capacity. (ICU according to IEC 60947-2 Clause 4)

f) Provided that the main switchboard is divided by a bus tie circuit breaker and that total discrimination (total selectivity) of generator circuit breaker and bus tie breaker are obtained, all circuit breakers in the main switchboard may be selected according to their rated ultimate breaking capacity. (ICU according to IEC 60947-2 Clause 4)

g) Generator circuit breakers and other circuit breakers with intentional short-time delay for short circuit release shall have a rated short-time withstand current capacity not less that the prospective short circuit current. (ICW according to IEC 60947-2 Clause 4)

h) Every protective device or contactor not intended for short circuit interruption shall be co-ordinated with the upstream protection device.

i) When a switchboard has two incoming feeders, necessary interlocks shall be provided against simultaneously closing of both feeders when the parallel connected short circuit power exceeds the switchboards' short circuit strength. A short time parallel feeding as a “make before break” arrangement is accepted when arranged with automatic disconnection of one of the parallel feeders within 30 s.

7.2.3 Fuses

a) Fuses above 320 A rating shall not be used as overload protection, but may be used for short circuit protection if otherwise acceptable according to these rules.

b) Used for short circuit protection, fuses can be rated higher than the full-load current, but not higher than expected minimum short circuit current.

c) In high voltage equipment, fuses shall not be used for overcurrent protection of power feeder circuits. Fuses may be used for short circuit protection provided they can be isolated and replaced without any danger of touching live parts.

7.2.4 Short circuit protection

The general requirements for circuit protection in 7.2.1, 7.2.2 and 7.2.3 apply with the following exceptions:

- separate short circuit protection may be omitted for motors serving different functions of the same nonimportant equipment for example the engine room crane may include hoisting, slewing and luffing motors.

Each motor should have separate overload protection and control gear

- separate short circuit protection may be omitted at the battery or busbar end of short circuit proof installed cables.

7.2.5 Overcurrent protection

a) Overcurrent protection shall not be rated higher or adjusted higher (if adjustable) than the cable's currentcarrying capacity, or the consumers nominal current, whichever is less.

b) The general requirements for circuit protection in 7.2.1, 7.2.2 and 7.2.3 apply with the following exceptions:

overcurrent protection may be omitted for circuits supplying consumers having overcurrent protection in their control gear this also applies to a circuit supplying a distribution switchboard with consumers having overcurrent protection in their control gear, provided that the sum of the rated currents of the control gears does not exceed 100% of the supply cable's rating.

7.2.6 Control circuit protection

The general requirements for circuit protection in 7.2.1, 7.2.2 and 7.2.3 apply with the following exceptions:

- protection may be omitted for monitoring circuits of automatic voltage regulators
- secondary side of current transformers shall not be protected
- the secondary side of the single phase voltage transformers shall be protected. The protection may be in one pole (phase) only
- separate protection may be omitted for control circuits branched off from a feeder circuit with nominal rating limited to 16 A
- separate protection may be omitted for control circuits branched off from a feeder circuit with nominal rating limited to 25 A and when the control circuit consists of adequately sized internal wiring only.

Adequately sized wiring means that the wiring withstands normal load and short circuit without reaching extreme temperatures.

7.3 Generator protection

7.3.1 Generator protection

a) Generators shall be fitted with short circuit and overcurrent protection.

b) The overcurrent protection shall normally be set so that the generator breaker trips at 110% to 125% of nominal current, with a time delay of 20 s to 120 s. Other settings may be accepted after confirmation of discrimination.

c) The short circuit trip shall be set at a lower value than the generator’s steady state short circuit current and with a time delay as short as possible, taking discrimination into account. Maximum 1 s.

d) Other forms for generator overload protection, for example winding over-temperature combined with power relays (watt metric relays), may substitute overcurrent protection provided the generator cables are sufficiently protected.

e) Generators having a capacity of 1500 kVA or above, and all high voltage generators, shall be equipped with suitable protection, which in the case of short circuit in the generator or in the supply cable between the generator and its circuit breaker will de-excite the generator and open the circuit breaker. Emergency generators are exempted.

f) When a generator is used for direct supply to single consumers, more than one generator breaker is acceptable. In such cases, the generator shall be de-excited and all the generator's breakers opened, in case of short circuit between the generator's terminals and the generator's breakers.

g) When a generator is installed outside the space where the switchboard with the generator circuit breaker is installed, the generator cable shall have short circuit protection at both ends. Alternatively, the generator shall be de-excited and the switchboard generator breaker opened, in case of short circuit between the generator's terminals and the generator breaker. An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the engine room, is not considered as separating the switchboard from the generator.

h) Each generator arranged for parallel operation shall be provided with a reverse-power relay with a time delay between 3 s and 10 s, tripping the generator circuit breaker at:

- maximum 15% of the rated power for generators driven by piston engines
- maximum 6% of the rated power for generators driven by turbines.

The release power shall not depart from the setpoint by more than 50% at voltage variations down to 60% of the rated voltage, and on AC installations at any power factor variation.

i) Generator circuit breakers shall be tripped at under-voltage. This under-voltage protection shall trip the breaker when the generator voltage drops within the range 70% to 35% of its rated voltage.

j) The under-voltage protection shall have a time delay allowing for correct operation of the short circuit protection (i.e. longer time delay than the short circuit protection.)

k) The under-voltage protection shall allow the breaker to be closed when the voltage and frequency are 85% to 110% of the nominal value.

l) The arrangement of short circuit-, overcurrent- and reverse power relays shall be such that it is possible to reconnect the circuit breaker within 30 s after a release, provided the voltage is within the range 85% to 110% of the rated voltage.

m) See Sec.5, 1.3.1 for requirements for temperature detectors in windings.

n) For emergency generators special requirements apply. See 3.3.2.

7.4 Transformer protection

7.4.1 Transformer protection

a) Transformers shall be fitted with circuit protection as required by 7.2.

b) If the primary side of transformers is protected for short circuit only, overcurrent protection shall be arranged on the secondary side.

c) For liquid filled transformers see Sec.6, 1.2.2.

When choosing the characteristics of protection devices for power transformer circuits it may be necessary to take current surge into consideration.

7.5 Motor protection

7.5.1 Motor protection

a) The general requirements for circuit protection in 7.2 apply.

b) Overcurrent protection for motors may be disabled during a starting period.

c) Overcurrent relays shall normally be interlocked, so that they must be manually reset after a release.

d) Short circuit and overload protection shall be provided in each insulated phase (pole) with the following exemptions:

- for DC motors, overcurrent relay in one pole can be used, but this cannot then substitute overcurrent release at the switchboard
- for AC motors supplied by three-phase electric power with insulated neutral, overload protection in any two of the three phases is sufficient
- overcurrent release may be omitted for essential or important motors, if desired, when the motors are provided with overload alarm
- overcurrent release in the control gear may be omitted when the circuit is provided with a switch-board circuit breaker with overcurrent protection
- overcurrent protection may be omitted for motors fitted with temperature detectors and being disconnected upon over temperature, provided the feeding cable is sufficiently protected.

e) See Sec.5, 1.3.1 for requirements for temperature detectors in windings.

7.6 Battery protection

7.6.1 Battery circuits

a) Circuits connected to batteries above 12 V or above 1 Ah capacity shall have short circuit and overcurrent protection. Protection may also be required for smaller batteries capable of creating a fire risk. Short circuit protection shall be located as close as is practical to the batteries, but not inside battery rooms, lockers, boxes or close to ventilation holes. The connection between the battery and the charger is also to have short circuit protection.

b) Connections between cells and from poles to first short circuit protection shall be short circuit proof, i.e. one of the methods described in Sec.13, 1.4.1 must be used.

c) The main circuit from a battery to a starter motor may be carried out without protection. In such cases, the circuit shall be installed short circuit proof, and with a switch for isolating purposes. Auxiliary circuits, which are branched off from the starter motor circuit, shall be protected as required in a).

7.7 Harmonic Filter protection

7.7.1 Harmonic filters

Each harmonic filter shall be protected against overcurrent and short circuit.

Circuit protection in filter circuits shall be monitored and provided with alarm in a manned control station.

Harmonic filters connected as network units (not as integrated parts of a converter) shall have isolating switchgear as required for important consumers in 6.1.1.

8 Control of Electric Equipment

8.1 Control circuits

8.1.1 General

All consumers other than motors shall be controlled by, at least, multi-pole switchgear, except that single pole switches can be used for luminaries or space heaters in dry accommodation spaces where floor covering, bulkhead and ceiling linings are of insulating material.

Multipole disconnection means that all active poles are disconnected simultaneously. However, any N-conductor is not regarded as an active pole, and need not be disconnected.

8.1.2 Power supply to control circuits

a) Power supply to control circuits for steering gear shall be branched off from the motor power circuit.

b) All other essential and important consumers control circuits may be arranged as in a) or they may be supplied by a control distribution system as long as:

- Consumers serving duplicated essential or important services are supplied by independent power supplies in accordance with 6.3.3.
- Supplies to consumers serving non-duplicated essential services and where the rules require two independent power supplies (main and back-up), are arranged in accordance with 6.3.3.
- The control circuit to each consumer has separate short circuit protection.

c) Upon failure of the power supply to essential and important functions, an alarm shall be initiated. In case of duplicated supplies, both shall be monitored.

8.2 Control of generator sets and main power supply

8.2.1 General

a) Tachometer feedback to the starting system shall be arranged so that mechanical or electrical failures do not lead to stop of a running generator unit. Neither shall such faults inhibit automatic stop or alarm functions.

b) The following alarms shall be arranged at a manned control station:

- power failure to the control system
- high and low frequency on the main busbars

- high and low voltage on the main busbars.

8.2.2 System for automatic start and stop of generator prime movers and automatic operation of breakers

Where start, stop and/or load sharing between generators are controlled by an automation system the following shall be arranged:

a) The following alarms shall be arranged at a manned control station:

- starting failure of prime mover
- excessive percentage difference in loads (kVA or alternatively both kW and kVAr) taken by the generators, with the necessary time delay, when in symmetrical load sharing mode.

b) Automatic starting attempts which fail shall be limited to restrict consumption of starting energy.

c) The generator circuit breaker shall be provided with automatic wind up of the closing spring of the breaker.

d) Simultaneous connection of generators on to the same bus shall not be possible.

e) Automatic connection of a generator during blackout shall only be possible when auxiliary contacts on all generator circuit breakers show directly that all generators are disconnected from the main switchboard and the bus is dead.

f) When a generator unit is standby, this shall be indicated on the control panel.

g) No more than one attempt of automatic connection per standby generator is permitted to a de-energized switchboard.

h) Systems with automatic start of the standby unit at heavy load on running units shall be arranged with adequate delay to prevent false start attempts, e.g. caused by short load peaks.

i) If the generator breaker has a “test” position, this shall be recognised by the control system as not available.

j) Automatic connection of generator shall not take effect before the voltage of the generator is stable and at normal level.

k) It shall be possible to select a minimum number of running generator sets or to deselect functions for automatic stop of generator sets at low load.

l) For requirements to system functionality, see 2.2.

8.3 Main and emergency switchboard control

8.3.1 General

a) Power supply for control circuits to generator breakers and generator protection shall generally be branched off from the main circuit (i.e. generator side for the generator breaker). For exception, see 8.3.2.

b) The interlocking circuit and protection relays shall be arranged so that the generator circuit breaker is not dependent of external power sources except for external power supplies mentioned in 8.3.2.

c) Where the main switchboard is arranged for operation from an automation system, the switchboard shall in addition be arranged for local operation at the front of the switchboard or at a dedicated control position within the switchboard room. This local operation shall be independent of remote parts of the automation system.

Exception:

For production systems, power plants not used for propulsion and steering e.g. process plant, alternative arrangement may be accepted.

d) Any casualty within one compartment of the main or emergency switchboard should not render more than one generator's circuit breakers, nor their instrumentation and signals, inoperative.

e) Requirements for automatic operation of generator breakers are given in 8.2.2.

f) For emergency generators, a trip of a control circuit protection shall not lead to uncontrolled closing of the generator breaker against a live bus.

8.3.2 Battery supplied control power

a) The power supply to the control circuits may be from a battery installation when arranged as required for starting batteries. Generator circuit breakers and other duplicated essential and important equipment shall be supplied from independent power supplies as described in 6.3.2.

b) An independent control power supply system shall be arranged for each of the switchboard sections and be arranged with change over possibilities.

c) Each auxiliary control power supply system shall have sufficient stored energy for at least two operations of all the components connected to its section of the switchboard. For switching off circuit breakers this applies for all circuit breakers simultaneously, and without excessive voltage drop in the auxiliary circuits, or excessive pressure drop in pneumatic systems.

8.3.3 Generator instrumentation

a) At any control position for manual operation of a generator breaker, including operator stations, the following information and control signals shall be easily and simultaneously observed by the operator:

- control and indication of breaker open and breaker close
- generator power (kW)
- generator current. Three separate simultaneous readings or alternatively one reading with a changeover switch for connection to all phases. If changeover switch is used, the current reading shall be supplied by separate current transformers, not used for protection. At an operating station one reading is sufficient.
- generator voltage
- generator frequency
- busbar voltage
- busbar frequency

- adjustment device for speed of generator prime mover. (Not required at operator stations if load sharing is controlled by the automation system.)

b) It shall be possible to synchronize each generator intended for parallel operation with two different devices.

Each such generator shall be able to be synchronized to its busbar by a synchronizing device independent of any other sections of the switchboard.

Alternatively one independent synchronizing device for each generator will be accepted.

Exception:

Synchronization of generators driven by propulsion engines may be achieved by adjusting the busbar frequency, i.e. by adjusting the speed/frequency set point(s) of the running generator(s).

8.3.4 Auxiliary generators and main switchboard in different locations

For generators installed in a space that does not have direct access to the space where the generator breaker is installed, the generator and generator driver shall be equipped with remote control and alarms as required by class notation AUT-UMS.

A generator installed in accordance with this will generally not be taken into account with respect to total generator capacity, see Sec.2/ 2.

8.3.5 Sectioning of busbars

a) Switchgear for sectioning of busbars shall have sufficient making and breaking capacity for the service for which it is intended. If wrong operation may cause damage, then instructions for correct operation shall be given by signboard on the switchboard. It shall be clearly indicated whether such switchgear is open or closed.

b) Under-voltage release of sectioning switchgear is accepted as long as the switchgear has sufficient capacity for breaking the prospective fault current at the point of installation.

8.3.6 Parallel incoming feeders

a) Switchboards that are arranged for supply by two (or more) alternative circuits shall be provided with interlock or instructions for correct operation by signboard on the switchboard. Positive indication of which of the circuits is feeding the switchboard shall be provided.

b) When a secondary distribution switchboard is supplied by two or more transformers or rectifiers, the circuit from each of these shall be provided with multipole switchgear.

c) Switchboards supplied from power transformers shall be arranged with interlock or signboard as in a) unless the power transformers are designed for parallel operation.

d) Interlocking arrangements shall be such that a fault in this interlocking system cannot put more than one circuit out of operation.

e) In the case where a secondary distribution system is supplied by parallel operated power transformers, supplied by different, non-synchronous systems, necessary interlocks shall be arranged to preclude parallel operation of the transformers when the primary sides are not connected.

f) Transformers shall not be energized from the secondary side, unless accepted by the manufacturer. For high voltage transformers, secondary side switchgear shall generally be interlocked with the switchgear on the primary side. This to ensure that the transformer will not be energized from the secondary side when the primary switchgear is opened. If back feeding through transformers is arranged, special warning signs shall be fitted on the primary side switchgear. Different generators shall not feed the different sides of transformers simultaneously (not locking generators in synchronism via a transformer).

Temporary back-feeding as part of a black-start procedure may be accepted.

8.4 Motor control

8.4.1 Control gear for motors

a) Each motor shall normally be provided with at least the following control gear, functioning independent of control gear for other motors:

- each motor rated 1 kW or above: a multipole circuit breaker, fused circuit breaker or contactor, with overcurrent release according to 7.5, if necessary combined with a controller for limiting the starting current
- each motor rated 1 kW or above: control circuits with under-voltage release so that the motor does not re-start after a blackout situation
- each motor rated less than 1 kW: a multipole switch.

b) Under-voltage release shall not inhibit intended automatic restart of motor upon restoration of voltage after a blackout.

c) Common starting arrangements for a group of motors (e.g. a group of circulating fans for refrigerated cargo holds) are subject to consideration in each case.

d) Control gear for motors shall be designed for the frequency of making and breaking operations necessary for the respective motor.

e) Switchgear for feeder circuits shall not be used as motor control gear unless:

- the switchgear is designed for the frequency of making and breaking operations necessary for the respective motor
- the requirements for motor control gear otherwise are complied with
- the switchgear shall be of the withdrawable type if low voltage.

f) For requirements to emergency stop, see 8.5.

8.4.2 Interlock for motor starting

a) If the starting of a motor requires that two or more generators are run in parallel, an interlock shall be provided, ensuring that this circuit can only be switched on when a sufficient number of generators are connected.

b) The interlock may, however, be omitted for motors that can only be started from the room where the generator breakers are located, provided signboards with the necessary instructions are fitted at the starters.

8.5 Emergency stop

8.5.1 Arrangement of emergency stop circuits

When emergency stop of a consumer is required by the rules, the following principles apply:

- The arrangement of the emergency stop system shall be such that no single failure will cause loss of duplicated essential or important equipment.
- The control circuits for emergency stop of duplicated equipment shall be arranged as two separate circuits with separate cables. A common stop button with several contacts (separate for each consumer) will be accepted.
- The emergency stop signal shall act independently of any software based control system for the same consumer.
- A computer based emergency stop systems shall be independent from other computer based systems with control functions for the same consumers. It shall have facilities to detect failures that will set the system inoperable, and give alarm to the main alarm system.
- Alarm for loss of power shall be provided for normally open emergency stop circuits.

Emergency stop systems may be based on both normally open (NO) and normally closed (NC) circuits, depending on the arrangement and the function of the system to be stopped. Systems, which can be stopped without any hazard, should be based on NC circuits, emergency stop of systems having effect on propulsion motors and thruster should be based on NO circuits.

8.5.2 Emergency stop of oil pumps and fans

a) Emergency stops of at least the following pumps and fans shall be arranged from an easily accessible position outside the space being served. These positions should not be readily cut off in the event of a fire in the spaces served:

- fuel oil transfer pumps
- fuel oil feed and booster pumps
- nozzles cooling pumps when fuel oil is used as coolant
- fuel and lubrication oil purifiers
- pumps for oil-burning installations
- fans for forced draught to boilers
- all ventilation fans
- all electrical driven lubrication oil pumps
- thermal oil circulating pumps

- hydraulic oil pumps in machinery space.

(Interpretation of SOLAS Reg. II-2/5.2.2)

b) The means provided for stopping the power ventilation of the machinery spaces shall be entirely separate from the means provided for stopping ventilation of other spaces.

Emergency stop will not be required for the following:

- fans not capable of supplying outside air to the space such as fans in HVAC temperature control units, fans for heating coils, ventilation fans for cabinets and switchboards, etc.
- pumps for systems containing less than 500 litre of flammable oil.

9 Vessel Arrangement

9.1 General

9.1.1 Ventilation

a) All rooms where electrical equipment is located shall be sufficiently ventilated in order to keep the environmental conditions within the limits given in Sec.3/ 2.3.

b) The heat generated by the electrical equipment itself, by other machinery and equipment, and the heat caused by sun radiation on bulkheads and decks should not lead to operating ambient temperatures in excess of the limits listed in Sec.3 Table 2.1.

c) The air supply for internal cooling of electrical equipment (i.e. “ventilated equipment”) shall be as clean and dry as practicable. Cooling air shall not be drawn from below the floor plates in engine and boiler rooms.

d) If forced ventilation or cooling is required, the same redundancy requirement applies to such equipment and its power supply as to the electrical equipment installed in the ventilated or cooled area.

e) Where the actual ambient air temperatures will clearly exceed the limits listed in Sec.3 Table 2.1, then the equipment shall be designed for the actual operating ambient temperatures concerned.

9.1.2 Arrangement of power generation and distribution systems

a) The arrangement of the main electric lighting system shall be such that fire, flood or other casualty, in spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard, will not render the emergency electric lighting system inoperative. (Interpretation of SOLAS Ch. II-1/41.2.2)

b) The arrangement of the emergency electric lighting system shall be such that fire, flood or other casualty, in spaces containing the emergency source of electrical power, associated transforming equipment, if any, the emergency switchboard and the emergency lighting switchboard, will not render the main electric lighting system inoperative. (Interpretation of SOLAS Ch. II-1/41.2.3)

c) The integrity of the main electrical supply shall be affected only by fire, flood or other damage conditions, in one space. The main switchboard shall be located as close as is practicable to the main generating station. (Interpretation of SOLAS Ch. II-1/41.3)

d) The main generating station shall be situated within the machinery space, i.e. within the extreme main transverse watertight bulkheads. Where essential services for steering and propulsion are supplied from transformers, converters and similar appliances constituting an essential part of electrical supply system they shall also satisfy the foregoing.

e) The integrity of the emergency electrical supply and the transitional source of power shall not be affected by fire, flood or other casualty in the main electrical supply, or in any machinery space of category A. The emergency switchboard shall be located in the same space as the emergency generating station. (Interpretation of SOLAS Ch. II-1/43.1.3 and 43.1.4)

f) Normally, the space containing the emergency source of power and associated electrical distribution shall not be contiguous to the boundaries of machinery space of category A or those spaces containing the main source of electrical power and associated electrical distribution. (Interpretation of SOLAS Ch. II-1/43.1.4)

Any bulkhead between the extreme main transverse watertight bulkheads is not regarded as separating the equipment in the main generating station provided that there is access between the spaces.

The requirements in a) do not preclude the installation of supply systems in separate machinery spaces, with full redundancy in technical design and physical arrangement.

9.2 Switchboard arrangement

9.2.1 Installation of switchboards

a) Switchboards shall be placed in easily accessible and well-ventilated locations, well clear of substantial heat sources such as boilers, heated oil tanks, and steam exhaust or other heated pipes. Ventilation and air conditioning systems shall be so arranged that possible water or condensation can not reach any switchboard parts. (Interpretation of SOLAS Ch. II-1/45.2)

b) Pipes shall not be installed so that switchgear may be endangered in the event of leaks. If installation of pipes close to the switchgear is unavoidable, the pipes should not have any flanged or screwed connections in this area.

c) Switchboards shall not be located immediately above spaces where high humidity or high concentrations of oil vapours can occur (e.g. bilge spaces), unless the switchboard has a tight bottom plate with tight cable penetrations.

d) The arrangement and installation of switchboards shall be such that operation and maintenance can be carried out in a safe and efficient way. When switchgear is located close to bulkheads or other obstructions, it shall be possible to perform all maintenance from the front.

e) Type tested assemblies or partially type tested assemblies with smaller clearance or creepage distances than given in Sec.3/ 4.6 (i.e. as accepted by Sec.4/ 1.1.8), are not accepted installed in machinery space category “A”.

f) For water-cooled electrical equipment seawater pipes shall be routed away from the equipment, so that any leakage in flanges do not damage the equipment.

9.2.2 Arrangement for high voltage switchboard rooms

The space where high voltage switchboards are installed shall be so arranged that hot gases escaping from the switchboard in case of an internal arc are led away from an operator in front of the switchboard.

9.2.3 Passage ways for main and emergency switchboards

a) Passages in front of main switchboards shall have a height of minimum 2 m. The same applies to passages behind switchboards having parts that require operation from the rear.

b) The width of the front passage shall be as given in Table 9.1.

c) Where switchgear needs passage behind for installation and maintenance work the free passage behind the switchgear shall be as given in Table 9.1.

d) The free passageway in front of, or behind the switchboard, shall give unobstructed access to a door for easy escape in case of an emergency situation occurring in the space.

Table 9.1

	Width of front passage		Width of passage behind	
System voltage	Unobstructed	With doors open or switchgear drawn out	Minimum free passage	Minimum free passage at frames
Below 500 V	0.8 m	0.4 m	0.6 m	0.5 m
500V≤ and ≤ 1 000 V	0.8 m	0.4 m	0.8 m	0.6 m
Above 1000 V	1.0 m	0.5 m	1.0 m	0.6 m

9.2.4 Distribution switchboards

a) Distribution switchboards shall be placed in accessible spaces with enclosures as specified in Sec.10.

b) Alternatively switchboards may be placed in cupboards made of or lined with material that is at least flameretardant, and with door, cable entrances and other openings (e.g. for ventilation) arranged so that the cupboard in itself complies with the protection required in Sec.10.

c) The front of the switchboard, inside such a cupboard, shall comply with enclosure type IP 20 with exemption for fuses as specified in Sec.4 / 1.1.3.

9.2.5 Control gear for equipment in bunker and cargo spaces

All lighting and power circuits terminating in a bunker or cargo space shall be provided with a multiple pole switch outside the space for disconnecting such circuits. (Interpretation of SOLAS Ch. II-1/45.8)

9.3 Rotating machines

9.3.1 General

a) Generating sets with horizontal shaft shall generally be installed with the shaft in the fore-and-aft direction of the vessel.

b) Where a large machine is installed athwartships, it should be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand the rolling specified in of the Rules for Classification of Ships. The manufacturer should be informed when a machine for installation athwartships is ordered.

c) Normally pipes shall not be installed above generators. If this is unavoidable, additional screening of flanges shall be required in order to protect the generator against splash, spray or leakage. Such screening shall be provided with drains, if necessary.

9.4 Battery installations

9.4.1 Application

These requirements are applicable to all types of rechargeable batteries.

Installation of battery types which may not produce explosive gasses but which may require other safety precautions will be evaluated on a case-by-case basis. Installation and ventilation recommendations from the manufacturer should always be followed.

9.4.2 Hazardous area

Requirements for installation of electrical equipment in battery rooms are given in Sec.11/ 3.2.4.

Table 9.2: Location and ventilation of vented type (liquid electrolyte)

Total capacity of batteries	Acceptable location	Acceptable ventilation
> 20 kVAh	Dedicated battery room	Mechanical extract ventilation to open air. If the ventilation fails, an alarm shall be given
>5 kVAh and ≤20 kVAh	Battery box with ventilation to open air	Natural ventilation, or mechanical extract ventilation with alarm when the ventilation fails.
≤ 5 kVAh	Battery box with ventilation holes at upper part of box	Ventilated to the room as described in 9.4.4.

Table 9.3: Location and ventilation of valve regulated/dry types

Total capacity of batteries	Acceptable location	Acceptable ventilation
> 100 kVAh	Dedicated battery room	Mechanical extract ventilation to open air. If the ventilation fails, an alarm shall be given
>5 kVAh and ≤ 100 kVAh	Battery box or open battery stand providing mechanical protection and human safety against touching of live parts (IP 10).	Natural ventilation to room as described in 9.4.4. Dry and well ventilated room
≤ 5 kVAh	Battery box or separate part of an electrical assembly	Ventilation holes at upper part of box. Also at lower part where found appropriate
≤5 kVAh and >0.2 kVAh	Inside an electrical assembly/enclosure	Mechanical ventilation
≤ 0.2 kVAh	Inside an electrical assembly/enclosure	Natural ventilated

9.4.3 Arrangement

a) Requirements for the location and ventilation of vented batteries are given in Table 9.2 and of valve regulated/dry batteries are given in Table 9.3.

b) Accumulator batteries shall be suitably housed, and compartments shall be properly constructed and efficiently ventilated.

- the batteries shall be so located that their ambient temperature remains within the manufacturer's specification at all times
- battery cells shall be placed so that they are accessible for maintenance and replacement
- in battery boxes, the cells shall be placed at one height only
- the space above cells shall be sufficient for maintenance and cooling
- normally, batteries shall not be located in sleeping quarters.

(Interpretation of SOLAS Ch. II-1/45.9.1 and 45.9.3)

c) Normally batteries shall not be located in a battery box at open deck exposed to sun and frost. Batteries may exceptionally be accepted located at open deck on the following conditions:

- the box shall be white in colour, and be provided with ventilation and heating
- the charger must be provided with temperature compensation capability.

d) Additional requirements for GMDSS batteries installed in accordance with c):

- the battery box shall be situated above the main muster stations.

Required capacity for GMDSS battery to be calculated according to the formula (for 1 hour and 6 hours of operation respectively, depending on provision of approved an emergency generator):

$$C_1 = 1.5\left[0.5(T_1 + T_2 + ... + T_M) + R_1 + R_2 + ... + R_M + L_{em}\right]$$

$$C_6 = 1.5\left[0.5(T_1 + T_2 + ... + T_M) + R_1 + R_2 + ... + R_M + L_{em}\right]6$$

Where:

T = power consumption of GMDSS transmitter 1 to M

R = power consumption of GMDSS receiver 1 to M

L = power consumption of emergency lighting

M = number of GMDSS transceivers.

9.4.4 Ventilation

a) Ventilation shall be arranged for all battery rooms, lockers and boxes. The air intake shall be in the lower part and can be taken from an adjacent room being readily accessible from the battery installation (e.g. ventilation from the engine room, for batteries with access from this room). The air outlet shall be arranged in the upper part so that gas pockets cannot accumulate.

b) Ventilation openings from rooms where batteries are installed shall be of a non-closable type suitable for all weather conditions.

Openings located lower than 4.5 m above the freeboard deck are subject to approval. For small vessels other suitable arrangement may be accepted.

c) Natural ventilation to open air shall be through an unobstructed duct not inclined more than 45 degrees from the vertical. The natural escape of air shall not be reduced by the room ventilation system; i.e. the room shall not have negative air pressure.

d) Ventilation rate, (m3/hour), for battery rooms and lockers with mechanical extract ventilation to open air shall comply with the following:

- for vented batteries, 10 x sum of battery kVAh
- for dry batteries, 2 x sum of battery kVAh.

e) Rooms into which battery lockers or boxes are ventilated shall have an extract ventilation duct at ceiling level. The area of the room (m^2) shall be at least 0.3 times battery kVAh. Ventilation rate of the room shall be at least 6 air changes per hour.

For vented batteries, a two step ventilation system applying reduced ventilation rate at trickle charging may be applied if the actual charging current is monitored. The monitoring circuit shall automatically switch to high ventilation rate when the value of the charging current in amperes, rises above 2% of the battery ampere hours value. Switching to low ventilation rate shall be by manual operation. The low ventilation rate, (m^3/hour) shall be at least

0.002 x sum of battery VAh.

In case of natural ventilation by openings to the room or by extract duct to free air, the following is given for cross section (cm^2) of openings and duct. Except for boxes, the inlet shall be of same size as the outlet.

- for dry batteries, 20 x battery kVAh
- for vented batteries, 50 x battery kVAh
- for dry batteries located in electrical panels, 500 x battery kVAh.

9.4.5 Charging station for battery powered fork lift

a) A charging station is defined as a separate room, only used for this purpose, or a part of a large room, for example a cargo hold, based on the area occupied by the fork lift plus 1 m on all sides.

b) Socket outlets for the charging cables, mechanically or electrically interlocked with switchgear, can be placed in the charging station. Such socket outlets shall have at least enclosure IP 44 or IP 56, depending upon the location (see Sec.10 Table 2.1). In general no other electrical equipment, except explosion protected equipment (according to Sec.11) as specified for battery rooms may be installed.

c) Charging stations shall generally be mechanically ventilated with at least 30 changes of air per hour. An arrangement as specified for battery rooms with battery capacity in accordance with the actual battery capacity, but not less than 20 kVAh shall be used, see 9.4.4. For charging stations in cargo holds having mechanical overpressure ventilation, an alternative arrangement shall provide a natural ventilation outlet duct of sufficient capacity from the upper part of the charging station to free air.

9.5 Cable routing

9.5.1 General

a) Cable runs shall be installed well clear of substantial heat sources such as boilers, heated oil tanks, steam, exhaust or other heated pipes, unless it is ensured that the insulation type and current rating is adapted to the actual temperatures at such spaces.

b) For installations in connection with hazardous areas, requirements for selection of cables, cable routing and fixing, see Sec.11. (Interpretation of SOLAS Ch. II-1/45.5.4)

c) Other requirements for cable routing and installation are located in Sec.10.

9.5.2 Separation of cables for emergency services, essential and important equipment

a) Where it is required to divide a ship into fire zones cable runs shall be arranged so that fire in any main vertical fire zone will not interfere with essential services in any other such zone. (Interpretation of SOLAS Ch. II-1/45.11)

b) The cables for duplicated steering gear motors shall be separated throughout their length as widely as is practicable. This also applies to control circuits for the steering gears motor starters, and to cables for remote control of the rudder from the bridge.

c) Cables and wiring serving essential, important or emergency equipment shall be routed clear of galleys, machinery spaces and their casings and other high fire risk areas, except for cables supplying equipment in those spaces. They shall not be run along fire zone divisions, so that heating through the division due to fire, jeopardise the function of the cables. Special attention shall be given to the protection and routing of main cable runs for essential equipment, for example between machinery spaces and the navigation bridge area, taking into account the fire risk existing in accommodation spaces. (Interpretation of SOLAS Ch. II-1/45.5.3)

d) Cables may exceptionally be routed through high fire risk area, but shall then have additional fire protection, e.g. by using cable tested in accordance with IEC 60331.

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, centralized motor starter panels, section boards and centralized control panels for propulsion and essential auxiliaries.

9.5.3 Separation of main generators or main power converters cabling

a) Cables for generators, transformers and converters required according to Sec.2, shall be divided between two or more cable runs. As far as practicable, these cable runs shall be routed away from each other and away from areas required to be protected by Fixed Water-Based Local Application Fire-Fighting Systems, i.e. boiler fronts, purifiers for heated fuel oil, the fire hazard portions of internal combustion machinery and incinerators.

b) In areas where it is impossible to separate the cable runs, they shall be protected against direct exposure to fire (e.g. screens or ducts or fire-protecting coating) and mechanical damage.

9.6 Lightning protection

9.6.1 General

a) All vessels with masts or topmasts made of non-conductive material shall be provided with lightning protection.

b) A lighting conductor shall be fitted on all non-metal masts on craft with a non-metal hull.

c) Primary conductors provided for lightning discharge currents shall have a minimum cross section of 70 mm^2 in copper or equivalent surge carrying capacity in aluminium.

d) The conductor shall be fastened to a copper spike of minimum diameter 12 mm reaching a minimum of 300 mm above the mast. The conductor shall terminate to a copper plate with a minimum area of 0.25 m^2 attached to the hull and so located that it is immersed under all conditions of heel.

e) Craft with a metal hull shall be fitted with a lightning conductor on all non-metal masts. The conductor shall be as required in c) and be terminated to the nearest point of the metal hull.

9.7 Earthing of aluminium superstructures on steel vessels

9.7.1 General

Aluminium superstructures that are provided with insulating material between aluminium and steel in order to prevent galvanic action, shall be earthed to the hull. For this purpose, corrosion-resistant metal wires or bands shall be used. The distance between each such connection shall be maximum 10 m. The sum of conductivities of all connections for one superstructure shall not be less than 50 mm^2 copper, and the conductivity of each connection shall not be less than 16 mm^2 copper.

Provisions shall be made for preventing galvanic action at the terminals of these connections (e.g. by using “Cupal” terminals when copper wires or bands are connected to the aluminium constructions).

With regard to radio interference, it may be necessary to use shorter spacing between the connections than the 10 m specified above.

10 Cable Selection

10.1 General

10.1.1 General

These technical requirements for cables and cable installations are considered relevant for the system design phase of a project. However, they apply as well to the final installation on the vessel.

Other relevant requirements related to cables can be found elsewhere in the rules, especially:

- 9.5 - requirements for the routing of electric cables
- Sec.9 - technical requirements for cables as electrical components
- Sec.10 - requirements for the installation of cables
- Sec.11 - requirements for cables used in hazardous areas.

10.1.2 Fire resistant cables

a) Cables for services, required to be operable under fire conditions shall be of fire resistant type complying with the requirements of IEC 60331-, where they pass through machinery spaces of category A and other high fire risk areas other than those which they serve. For passenger vessels this requirement also applies for cables passing through main vertical fire zones. (IACS UR E15)

b) Systems that are self-monitoring, fail safe or duplicated with runs as widely as is practicable may be exempted.

c) The following electrical services are required to be operable under fire conditions:

- fire and general alarm system
- fire extinguishing systems and fire extinguishing medium alarms
- 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 lighting
- public address system
- low location lighting
- — emergency fire pump (IACS UI SC 165)
- remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and or explosion (IACS UR E 15).

“High fire risk areas” in the context of above Rules are:

- machinery spaces of category A,
- galleys and pantries containing cooking appliances,
- laundries containing drying equipment,

- saunas,
- sale shops, barber shops and beauty parlours,
- paint lockers and other store-rooms for flammable liquids.

10.1.3 Voltage rating

a) The rated voltage of a cable shall not be less than the nominal voltage of the circuits in which it is used.

It is recommended that cables used for semiconductor converters for motor drives are selected with increased voltage rating in order to withstand voltage transients. Maker's recommendations should be followed.

b) Cables designed in accordance with Sec.9/ 5.1 are only accepted for use in control and instrumentation systems up to 250 V.

c) In power distribution systems, with system voltage up to 250 V, 0.6/1 kV power cables in accordance with Sec.9/ 4.1 shall be used.

Cables designed in accordance with IEC 60092-376 is not accepted as power cable, and can therefore not be used for light circuits etc, only instrumentation and control circuits

d) In systems with high-resistance earthed neutral the rated phase to earth voltage (U0) of the cables shall not be less than given in Table 10.1.

e) In systems with insulated neutral (IT-systems), the rated phase to earth voltage (U0) of the cables shall be as for systems with high-resistance earthed neutral without automatic disconnection upon earth fault.

Guidance note:

- 0.6/1 kV cables may be accepted in 690 V distribution system
- 3.6/6 kV cables may be accepted in 6.6 kV distribution systems with automatic disconnection upon earth fault if accepted by manufacturer.

10.1.4 Colour code on earthing cable

Colour code is not required on earthing cables. However if yellow/green colour code is used, it shall be used for protective earthing only.

10.1.5 Cable separation and protection

Separate cables shall be used for circuits provided with separate short circuit or over current protection except for:

- control circuits branched off from a main circuit may be carried in the same cable as the main circuit
- multicore cables used intrinsically safe circuits see Sec.11/ 4.2.6
- special cables such as umbilicals to be considered in each case.

Table 10.1: Rated voltage for high voltage cables

Highest system voltage (Um)(kV)	Rated voltage (U_0)(kV)	
	With automatic disconnection upon earth fault	Without automatic disconnection upon earth fault
7.2	3.6	6.0
12.0	6.0	8.7
17.5	8.7	12.0
24.0	12.0	18.0
36.0	18.0	-

10.2 Cable temperature

10.2.1 Cable temperature class

The temperature class of power cables shall be at least 10°C above the ambient temperature.

10.3 Choice of insulating materials

10.3.1 Short circuit and cable

The conductor cross-section of cables shall be sufficient to prevent the insulation from being damaged by high temperatures occurring by short circuits at the cable end. The conductor temperature classes are given in IEC 60092-351.

10.3.2 PVC insulated conductors and switchboard wires

a) PVC-insulated conductors without further protection may be used for installation in closed piping system in accommodation spaces, when the system voltage is maximum 250 V.

b) PVC-insulated conductors may be used for internal wiring of switchboards and other enclosures, and for control wiring installed in closed piping system. Other types of flame retardant switchboard wires may be accepted for the same purpose. See Sec.9.

10.3.3 PVC insulated cables

Due to brittleness at low temperatures, cables with PVC insulation and or inner/outer sheath, shall normally not be installed in refrigerated chambers, and holds for temperatures below - 20°C, or across expansion joints on weather decks.

10.3.4 Silicon rubber insulated cables

Due to poor mechanical strength, the use of silicon-rubber-insulated cables is limited to applications where a high temperature resistant cable is necessary (where the ambient temperature can be above 70°C).

10.4 Rating of earth conductors

10.4.1 Earthing connections and conductors

a) All earthing connections of copper shall have sufficient cross-section to prevent the current density exceeding 150 A/mm^2 at the maximum earth fault currents that can pass through them.

b) Minimum cross-section of earthing conductors shall be as listed in Table 10.2.

Table 10.2: Earthing connections and conductors

Arrangement of earth conductor		Cross-section Q of associated current carrying conductor (one phase or pole) (mm^2)	Minimum cross-section of earth conductor
1	i) Insulated earth conductor in cable for fixed installation. ii) Copper braid of cable for fixed installation. iii) Separate, insulated earth conductor for fixed installation in pipes in dry accommodation spaces, when carried in the same pipe as the supply cable. iv) Separate, insulated earth conductor when installed inside enclosures or behind covers or panels, including earth conductor for hinged doors as specified in Sec.10 /2.	$Q \leq 16$	Q
		$16 < Q$	1/2 of the current-carrying conductor, but not less than 16 mm^2
2	Uninsulated earth conductor in cable for fixed installation, being laid under the cable's lead sheath, armour or copper braid and in metal-to-metal contact with this	$Q \leq 2.5$	1 mm^2
		$2.5 < Q \leq 6$	1.5 mm^2
		$6 < Q$	Not permitted
3	Separately installed earth conductor for fixed installation other than specified in 1 iii) and 1 iv)	$Q < 2.5$	Same as current-carrying conductor subject to minimum 1.5 mm^2 for stranded earthing connection or 2.5 mm^2 for unstranded earthing connection
		$2.5 < Q \leq 120$	1/2 of current-carrying conductor, but not less than 4 mm^2
		$120 < Q$	70 mm^2
4	Insulated earth conductor in flexible cable	$Q \leq 16$	Same as current-carrying conductor
		$16 < Q$	1/2 but minimum 16 mm^2

10.5 Correction factors

10.5.1 Different temperature classes

If cables of different temperature classes are carried in the same bunch or pipe, the current ratings for all cables shall be based on the lower temperature class.

10.5.2 Multicore cables

For cables with more than 4 cores, the current rating are given by the following equation:

$$J_N = J_1 / \sqrt[3]{N}$$

N = number of cores

J_1 = the current rating for a single-core cable.

This applies by equal load on all cores. If some cores in such multi-core cables are not used, or are used for very small currents only, the current rating for the other cores may be increased after consideration in each case.

10.5.3 Ambient temperature

When the actual ambient air temperature clearly differs from 45°C, the correction factors as given in Table 10.8 apply.

10.5.4 Bunching

The current ratings specified in the Tables 10.3 to 10.7 are based on maximum 6 cables, which can be expected to be under full load simultaneously being bunched together. If bunching of larger formations is used for cables expected to be under full load simultaneously, a correction factor of 0.85 shall be applied.

10.5.5 Periodic load

For cables used for loads that are not continuous, i.e. operates for periods of half or one hour and the periods of no-load is longer than 3 times the cable time constant T (in minutes), the current rating may be increased by a duty factor, D_f, calculated from:

$$D_f = \sqrt{\frac{1.12}{1-e^{-ts/T}}}$$

ts = the service time of the load currents in minutes

T = cable's time constant

= $0.245\ d^{1.35}$

d = overall diameter of the cable in mm.

10.5.6 Intermittent load

Cables used for loads that are not continuous, are repetitive and have periods of no-load of less than 3 times the cable time constant T (in minutes), the current rating may be increased by an intermittent factor, I_f, calculated from:

$$I_f = \sqrt{\frac{1-e^{-tp/T}}{1-e^{-ts/T}}}$$

ts = the service time of the load currents in minutes

tp = the intermittent period in minutes (i.e. the total period before of load and no-load before the cycle is repeated)

ts, T and d, see 10.5.5.

10.6 Parallel connection of cables

10.6.1 General

a) Parallel connection can be used for cables having conductor cross-section 10 mm² or above. All cables that are parallel connected shall be of the same length, cross-section and construction. The current-carrying capacity is the sum of all parallel conductors' current-carrying capacities.

b) A two, three or four-core cable, in which all cores are of the same cross-section, can be used as single-core cable by parallel connection of all cores in each end. The current-carrying capacity of such single-core cable is the sum of the cores' current-carrying capacities.

c) With parallel connection of multi-core cables, one core of each cable shall be used for each phase and neutral connection, respectively.

d) With many parallel-connected cables, the current distribution may be uneven. However, no single cable shall, after installation, carry more than its capacity. This shall be demonstrated at full load of the consumer.

10.7 Additional requirements for AC installations, and special DC installations

10.7.1 General

a) Generally, multi-core cables shall be used on AC installations.

b) On three-phase, four-wire circuits, the cross-section of the neutral conductor shall be the same as for a phase conductor up to 16 mm^2, and at least 50% of that of a phase conductor for larger cross-sections, though not larger than 50 mm^2. The braiding in a cable shall not be used as the neutral conductor.

c) The neutral conductor shall normally be a part of the power supply cable. Separate neutral cable may be accepted for cross section above 16 mm^2, if the power cable not is provided with magnetic braiding.

10.7.2 Single-core cables

a) Single-core cables shall not have steel-wire braid or armour when used in AC systems and DC systems with a high “ripple” content.

b) See Sec.10/ 3.2.4 and 3.5.6 for fixing of single core cables.

10.8 Rating of cables

10.8.1 Conductor current rating

The highest continuous load carried by a cable shall not exceed the current rating specified in Tables 10.3 to 10.7, with consideration given to the correction factors given in 10.5.

Cables used in circuits with non-sinusoidal currents should be de-rated in order to compensate for the additional heat losses. Maker’s recommendations should be followed.

Table 10.3: Rating of cables with temperature class 60°C

Nominal cross-section (mm^2)	Current rating (A)(Based on ambient temperature 45°C)					
	Single-core		2-core		3 or 4-core	
1	8		7		6	
1.5	10		9		7	
2.5	17		14		12	
4	23		20		16	
6	29		25		20	
10	40		34		28	
16	54		46		38	
25	71		60		50	
35	88		75		62	
50	110		94		77	
70	135		115		95	
95	164		139		115	
120	189		161		132	
150	218		185		153	
185	248		211		174	
240	292		248		204	
300	336		286		235	
	DC	AC	DC	AC	DC	AC
400	390	380	332	323	273	266
500	450	430	383	366	315	301
630	520	470	442	400	364	329

Table 10.4: Rating of cables with temperature class 70°C

Nominal cross-section (mm^2)	Current rating (A)(Based on ambient temperature 45°C)					
	Single-core		2-core		3 or 4-core	
1.5	15		13		11	
2.5	21		18		15	
4	29		25		20	
6	37		31		26	
10	51		43		36	
16	68		58		48	
25	90		77		63	
35	111		94		78	
50	138		117		97	
70	171		145		120	
95	207		176		145	
120	239		203		167	
150	275		234		193	
313	185		266		219	
369	240		314		258	
424	300		360		297	
	DC	AC	DC	AC	DC	AC
400	500	490	425	417	350	343
500	580	550	493	468	406	385
630	670	610	570	519	469	427

Table 10.5: Rating of cables with temperature class 85°C

Nominal cross-section (mm^2)	Current rating (A)(Based on ambient temperature 45°C)					
	Single-core		2-core		3 or 4-core	
1	16		14		11	
1.5	21		18		15	
2.5	28		24		20	
4	38		32		27	
6	49		42		34	
10	67		57		47	
16	91		77		64	
25	120		102		84	
35	148		126		104	
50	184		156		129	
70	228		194		160	
95	276		235		93	
120	319		271		223	
150	367		312		257	
185	418		355		293	
240	492		418		344	
300	565		480		396	
	DC	AC	DC	AC	DC	AC
400	650	630	553	536	445	441
500	740	680	629	578	518	476
630	840	740	714	629	588	518

Table 10.6: Rating of cables with temperature class 90°C

Nominal cross-section (mm^2)	Current rating (A)(Based on ambient temperature 45°C)					
	Single-core		2-core		3 or 4-core	
1	18		15		13	
1.5	23		20		16	
2.5	30		26		21	
4	40		34		28	
6	52		44		36	
10	72		61		50	
16	96		82		67	
25	127		108		89	
35	157		133		110	
50	196		167		137	
70	242		206		169	
95	293		249		205	
120	339		288		237	
150	389		331		272	
185	444		377		311	
240	522		444		365	
300	601		511		421	
	DC	AC	DC	AC	DC	AC
400	690	670	587	570	483	469
500	780	720	663	612	546	504
600	890	780	757	663	623	546

Table 10.7: Rating of cables with temperature class 95°C

Nominal cross-section (mm^2)	Current rating (A)(Based on ambient temperature 45°C)					
	Single-core		2-core		3 or 4-core	
1	20		17		14	
1.5	26		22		18	
2.5	32		27		22	
4	43		37		30	
6	55		47		39	
10	76		65		53	
16	102		87		71	
25	135		115		95	
35	166		141		116	
50	208		177		146	
70	256		218		179	
95	310		264		217	
120	359		305		251	
150	412		350		288	
185	470		400		329	
240	553		470		387	
300	636		541		445	
	DC	AC	DC	AC	DC	AC
400	760	725	646	616	532	508
500	875	810	744	689	612	567
600	1010	900	859	765	707	630

Table 10.8: Correction factors for ambient temperature

Cable temperature class	Ambient temperature (°C)										
°C	35[1)]	40	45	50	55	60	65	70	75	80	85
60[2)]	1.29	1.15	1.00	0.82	-	-	-	-	-	-	-
70	1.18	1.10	1.00	0.89	0.77	0.63					
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

1) Correction factors for ambient temperature below 40°C will normally only be accepted for:

- cables in refrigerated chambers and holds, for circuits which only are used in refrigerated service
- cables on vessel with class notation restricting the service to non-tropical water.

2) 60°C cables shall not be used in engine and boiler rooms.

Section 3 Equipment In General

1 General Requirements

1.1 References

1.1.1 General

a) This section contains technical requirements for all electrical equipment in general. Additional requirements for special types of equipment can be found in Sec.4 to Sec.9.

b) Requirements for electrical systems as a whole can be found in Sec.2. Requirements for installation of equipment can be found in Sec.10.

3.1.2 Compliance with standards

The requirements in this section are based on the IEC standard system in general.

IEC Standards covering the general requirements for electrical components for ships are:

IEC 60092-101 "Definitions and general requirements", and parts of IEC 60092-201 "Systems design - General".

2 Environmental Requirements

2.1 Inclinations

2.1.1 General

a) Electrical equipment and components on ships shall be designed to operate satisfactorily under the following inclinations of the vessel:

- static conditions: list 15º, trim 5°
- dynamic conditions: rolling ± 22.5º, pitch ± 7.5º (may occur simultaneously)

b) Emergency installations on ships, except as stated in c), shall be designed to operate satisfactorily under the following inclinations of the vessel:

- static conditions: list 22.5°, trim 10°.

(Interpretation of SOLAS Ch. II-1/43.6)

c) On ships for the carriage of liquefied gases and chemicals, the emergency power supply shall remain operational with the ship flooded up to a maximum final athwart ship inclination of 30º, when the deck is not immersed.

Other values may be accepted if justified by calculations for the particular vessel.

National authorities may require larger inclinations.

2.2 Vibrations and accelerations

2.2.1 General

a) Electrical equipment and components shall be constructed to withstand, without malfunctioning, or electrical connections loosening, at least the following values:

- vibration frequency range 5 to 50 Hz with vibration velocity amplitude 20 mm/s
- peak accelerations ± 0.6 g for vessels of length exceeding 90 m (duration 5 to 10 s)
- peak accelerations ±1 g for vessels of length less than 90 m (duration 5 to 10 s).

b) For flexible mounted equipment, special considerations shall be given to the construction of the equipment since larger vibrations may occur.

2.3 Temperature and humidity

2.3.1 Ambient temperatures

a) Electrical equipment including components inside enclosures in switchboards etc., shall be constructed for continuous operation at rated load, at least within the ambient air temperature ranges listed in Table 2.1 and cooling water temperatures in 2.3.2.

b) Modifications of the equipment may be required if the actual ambient air temperatures will clearly exceed the limits in a).

c) If some equipment has a critical maximum ambient temperature by which it suddenly fails, this critical temperature should not be less than 15°C above the limits specified in the table.

d) For vessels with class notation restricting the service to non-tropical waters, the upper ambient air temperature limits according to Table 2.1 may be reduced by 10°C.

Table 2.1: Ambient air temperature ranges

<table>
<tr><td colspan="3" rowspan="2">Location</td><td colspan="2">Minimum ambient air temperature range for continuous operation (°C)</td></tr>
<tr><td>From</td><td>To</td></tr>
<tr><td>1</td><td></td><td>Engine rooms, boiler rooms, galleys and similar spaces, accommodation spaces.</td><td>0</td><td>+45</td></tr>
<tr><td>2</td><td></td><td>Open deck, dry cargo holds, steering gear compartments, deckhouses,forecastle spaces and similar spaces which are not provided with space heating.</td><td>-25</td><td>+45</td></tr>
<tr><td rowspan="2">3</td><td>a)</td><td>Refrigerated chambers and holds, general.</td><td rowspan="2">The minimum temperature specified for the installation, but not above</td><td>+45</td></tr>
<tr><td>b)</td><td>Refrigerated chambers and holds, for equipment which only is used in refrigerated service.</td><td>+35</td></tr>
</table>

These rules do not appraise ambient conditions for transport or storage of electrical equipment.

2.3.2 Cooling water temperatures

Electrical equipment shall be constructed for continuous operation under full rated load, at a seawater temperature range from 0 to +32°C. Electrical equipment on vessels with class notation restricting the service to non-tropical waters shall be constructed for continuous operation at a seawater temperature range from 0 to +25°C.

2.3.3 Humidity

Electrical equipment shall be constructed to withstand, and function safely in relative humidity up to 95%.

3 Equipment Ratings

3.1 Electrical parameters

3.1.1 General

a) Unless otherwise clearly stated by the purchaser, equipment shall be rated for continuous duty.

b) All conductors, switchgear and accessories shall be of such size as to be capable of carrying, without their respective ratings being exceeded, the current which can normally flow through them. They shall be capable of carrying anticipated overloads and transient currents, for example the starting currents of motors, without damage or reaching abnormal temperatures.

3.1.2 Voltage and frequency

a) Equipment connected to the system shall be constructed for the system's nominal frequency and voltage, voltage drop in distribution, and the tolerances described in Sec.2/ 1.2.

b) With respect to fast voltage transients, equipment connected to the system shall be capable of withstanding fast transients with peak voltage amplitude of 5.5 times U_N, and rise time/delay time of 1.2 μs/50 μs, respectively.

c) Any special system, e.g. electronic circuits, whose function cannot operate satisfactorily within the limits given in Sec.2/ 1.2 should not be supplied directly from the system but by alternative means, e.g. through stabilized supply.

3.1.3 Harmonic distortion

All equipment shall be designed to operate at any load up to the rated load, with a supply voltage containing the following harmonic distortion:

- total harmonic content not exceeding 8% of voltage root mean square value
- no single harmonic being greater than 5% of voltage root mean square value.

3.1.4 For distribution systems with harmonic distortion, see Sec.2/ 1.2.7.

3.1.5 Electromagnetic compatibility (EMC)

Equipment producing transient voltage, frequency and current variations shall not cause the malfunction of other equipment on board, neither by conduction, induction or radiation.

3.2 Maximum operating temperatures

3.2.1 General

a) The temperature rise of enclosures and their different exterior parts shall not be so high that fire risk, damage to the equipment, adjacent materials or danger to personnel occurs. The temperature rise shall not exceed 50°C. Exemptions may be considered for equipment that is especially protected against touching or splashing of oil.

b) For enclosures installed in contact with flammable materials such as wooden bulkheads, the temperature rise limit is 40°C.

c) For luminaries, resistors and heating equipment, see Sec.8.

d) Maximum temperature for operating handles is:

- handles and grips made of metal: 55°C
- handles and grips made of insulating material (porcelain, moulded material, rubber or wood): 65°C.

Higher temperatures may be accepted for parts which normally will not be handled with unprotected hands.

4 Mechanical and Electrical Properties

4.1 Mechanical strength

4.1.1 General

Equipment shall have sufficient mechanical strength to withstand the strains they are likely to be exposed to when installed.

4.1.2 Enclosures

a) Enclosures shall be resistant to weather, oil and chemicals and have sufficient mechanical strength when intended to be installed in an area where risk of mechanical damage exists.

b) Metallic enclosures installed on deck or in compartments where severe corrosion problems can be expected shall be made of especially corrosion resistant material or dimensioned with a certain corrosion allowance.

c) Light metal alloys as i.e. aluminium shall be avoided as enclosure materials if not documented to be seawater resistant and installed so that local corrosion caused by contact does not occur.

d) Enclosures that are so placed that they are likely to be stepped or climbed on, shall be able to withstand the weight of a man. This applies for example to most electrical machines in the engine room, winch motors on deck, etc. A test to this effect, with a force of 1000 N applied by a flat surface 70 x 70 mm, may be carried out as type test or random test.

e) Enclosures shall withstand the ambient air temperatures which are specified in B, with the equipment at full load. The temperature rise of enclosures shall not be so high that fire risk, damage to adjacent materials or danger to personnel occurs.

f) When enclosures of other materials than metal are used, they should at least withstand immersion in water at 80°C for 15 minutes, without showing signs of deterioration, and the material shall be flame retardant according to IEC 60092-101. A test to this effect may be carried out as type test or random test. This also applies to screens of luminaries, and to windows in other enclosures, if made of other material than glass.

4.1.3 Materials

a) Electrical equipment shall be constructed of durable non-hygroscopic materials which are not subject to deterioration in the atmosphere to which it is likely to be exposed.

b) Electrical equipment shall be constructed of at least flame retardant materials.

Even in “dry” locations, up to 96% relative humidity with a salt content of 1 mg salt per 1 m^3 of air may occur; in machinery spaces also mist and droplets of fuel- and lubricating oil.

Tests for flame retardant properties are described in IEC 60092-101. Flammability test in accordance with UL94 5VA, 5VB, V0 and V1 can also be accepted.

For minor equipment or non metallic parts of electrical components a glow wire test in accordance with IEC 60695-2-11 may be accepted. Parts of insulation material necessary to retain current-carrying parts should conform to a test temperature of 960 ºC.

4.1.4 Material deterioration due to cargo vapours

Where the cargo gases or vapours are liable to damage the materials used in the construction of electrical apparatus, careful consideration shall be given to the characteristics of the materials selected for conductors, insulation, metal parts, etc. As far as is practicable, components of copper and aluminium, shall be encapsulated to prevent contact with gases or vapours.

Attention is drawn to the possibility of gases and vapours being transferred from one point to another through cables or cable ducting unless appropriate precautions are taken, for example, adequate end sealing.

4.2 Cooling and anti-condensation

4.2.1 General

a) Where electrical equipment depends on additional cooling, the following shall be complied with:

- an alarm shall be initiated when auxiliary cooling or ventilation motors stop running. Alternatively a flow monitoring alarm shall be initiated
- the windings in the cooled equipment for essential services shall be equipped with temperature detectors for indication and alarm of winding temperature
- the windings in the cooled equipment for important services shall be equipped with temperature detectors for alarm at high winding temperature.

b) Where the cooling of electrical equipment depends upon general room ventilation only, temperature detectors in the equipment are not required.

4.2.2 Water cooled heat exchangers

a) Where cooling of equipment is arranged through air-water heat exchangers, these shall be arranged to prevent entry of water into the equipment, whether by leakage or condensation. Leakage alarm shall be provided.

b) Heat exchangers in high voltage equipment shall be of double tube type and shall be fitted with leakage alarm.

c) The construction and certification of the air-water heat exchangers shall comply with the requirements for pressure vessels, see Ch.1, Sec5.

d) For direct water cooling of semi-conductor equipment, see Sec.7.

4.2.3 Anti condensation

a) For equipment where condensation is likely, for example those that are idle for long periods, heating arrangements may be required.

b) All high voltage converters, transformers and rotating equipment not located in heated and ventilated spaces, shall be provided with heating elements in order to prevent condensation and accumulation of moisture. The heating shall be automatically switched on at stand still.

c) All equipment equipped with air/water heat exchangers shall be provided with heating elements in order to prevent condensation and accumulation of moisture. The heating shall be automatically switched on at stand still.

4.3 Termination and cable entrances

4.3.1 Termination

a) All equipment shall be provided with suitable, fixed terminals in an accessible position with sufficient space for dismantling and connection of external incoming cables. Twist-on or clamp-on connections inside connection boxes for lighting and small power consumers are accepted inside dry accommodation.

b) All connections for current-carrying parts and earthing connections shall be fixed so that they cannot loosen by vibration. This also applies to fixing of mechanical parts when found necessary.

c) Terminals for circuits with different system voltages shall be separated, and clearly marked with the system voltage.

d) High voltage terminals, above 1000 V, shall not be located in the same box, or part of enclosure, as low voltage terminals.

e) Electrical equipment that needs to be connected to protective earth according to 400 shall be provided with suitable fixed terminal for connecting a protective earth conductor. The terminal shall be identified by a symbol or legend for protective earthing (PE).

4.3.2 Cable entrance

a) Cable entrance shall be so arranged that the enclosure keep its intended IP rating after installation and in operation.

b) Cable entrances shall be fit for the outer diameter of the cable in question.

Cable entries from the top on equipment installed on open deck should be avoided unless other alternatives prove impracticable.

4.4 Equipment protective earthing

4.4.1 General

a) Exposed parts of electrical installations, other than current carrying parts which are liable, under fault conditions to become live, shall be earthed. Fixing devices between a high voltage enclosure and steel hull parts shall not be relied upon as the sole earthing connection of the enclosure.

b) Switchgear and control gear assemblies shall be fitted with earth connection(s) to ensure earthing of all metallic non-current carrying parts. In main and emergency switchboards a continuous earth-bar is required for this purpose.

c) For the interconnections within an enclosure, for example between the frame, covers, partitions or other structural parts of an assembly, the fastening, such as bolting or welding is acceptable, provided that a satisfactory conductive connection is obtained.

d) Compartment doors with components such as switches, instruments, signal lamps, etc. with voltage exceeding 50 V AC or DC shall be connected to the switchboard or enclosure by a separate, flexible copper earth conductor. In high voltage equipment, this conductor shall have at least 4 mm² cross-section. A compartment door can be earthed through its metallic hinges when it not carries any electric components.

In high voltage equipment, this conductor shall have at least 4 mm² cross-section.

e) Each high voltage assembly shall be earthed by means of earth conductors. Each assembly shall be provided with a main earthing conductor of cross-section at least 30 mm² copper, with at least 2 adequate terminals for connection to the steel hull. Each unit enclosure and other metallic parts intended to be earthed shall be connected to this main earthing conductor or bar.

f) Earthed metallic parts of withdrawable components in high voltage equipment shall remain earthed, by means of a special earth device, until they have been fully withdrawn. The earthing shall be effective also when in test position with auxiliary circuits live.

g) The secondary winding of any current or voltage transformer installed in a high voltage system shall be earthed by a copper conductor of at least 4 mm2 cross-section. Alternatively, unearthed secondary winding with overvoltage protection is accepted.

Exception:

Exception from this requirement is given for machines or equipment:

- supplied at a voltage not exceeding 50 V DC or AC between conductors
- supplied at a voltage not exceeding 250 V by safety isolating transformers supplying only one consuming device. Auto-transformers may not be used for the purpose of achieving this voltage

- constructed in accordance with the principle of double insulation. (Interpretation of SOLAS Ch. II-1/45.1.1)

4.5 Enclosures ingress protection

4.5.1 General

a) All equipment shall be constructed to prevent accidental touching of live parts, and shall have enclosures with a minimum degree of protection dependent upon the installation area, according to the installation requirements in Sec.10/ Table 2.1, unless a higher degree is required by these rules.

b) For equipment supplied at nominal voltages above 500 V up to and including 1000 V, and which is accessible to non-qualified personnel, it is in addition required that the degree of protection against touching live parts shall be at least IP 4X.

c) High voltage switchgear and control gear assemblies shall have enclosure type of at least IP 32.

d) High voltage transformers shall have enclosure type of at least IP 23, when located in spaces accessible only to qualified personnel, and at least IP 54 in other locations.

e) High voltage rotating electrical machines shall have a degree of protection by enclosure of at least IP 23, unless a higher degree is required by location. Connection boxes of high voltage rotating machines shall in all cases have a degree of protection of at least IP 44.

f) A separate locked room with warning signs, and without other installations, can be regarded as an enclosure by itself, that is, no requirement for equipment protection applies.

Equipment located in machinery spaces may be considered as being accessible to qualified personnel only. The same applies to equipment located in other compartments that normally are kept locked, under the responsibility of the ship's officers.

4.6 Clearance and creepage distances

4.6.1 General

The distance between live parts of different potential and between live parts and the cases of other earthed metal, whether across surfaces or in air, shall be adequate for the working voltage, having regard to the nature of the insulating material and the conditions of service.

4.6.2 Clearance and creepage distances for low voltage equipment

The minimum clearance and creepage distances for bare busbars in low voltage equipment are given in Table 4.1, and shall be complied with when insulating materials with tracking index 175 V are used. For type tested assemblies and partially type tested assemblies the distances given in Sec.4/ 1.1.8 may apply.

For frequency converters, see Sec.7.

4.6.3 Clearance and creepage distances for high voltage equipment

a) The minimum clearance distance in high voltage equipment shall be suitable for the rated voltage having regard to the nature of the insulating material and the transient over voltages developed by switching and fault conditions. This requirement may be fulfilled by subjecting each assembly type to an impulse voltage type test according to Table 4.3. Alternatively, maintaining the minimum distances given in Table 4.2.

b) Minimum creepage distances for main switchboards and generators are given in Table 4.4, and for other equipment in 4.5.

c) All insulating materials for fixing and carrying live parts shall have tracking index of at least 300 V according to IEC 60112.

d) Within the busbar section of a switchgear assembly the minimum creepage distance shall be at least 25 mm/ kV for non standardised parts. Behind current limiting devices the creepage distance shall be at least 16 mm/kV. (IACS E11 2.3.2)

Table 4.1: Low voltage busbar clearances or creepage between phases (including neutral) and between phases and earth

Rated insulation voltage, AC root mean square or DC (V)	Minimum clearances (mm)	Minimum creepage distances (mm)
Up to 250 V	15	20
From 250 to 690 V	20	25
Above 690 V (Maximum 1000 V)	25	35

Table 4.2: Clearances for high voltage equipment between phases (including neutral) and between phases and earth

Nominal voltage of the system, (V) 1)	Minimum clearance distance for (mm)	
	Main switchboards and generators	Other equipment
1000 - 1100	25	25
3000 - 3300	55	55
6000 - 6600	90	90
10000 - 11000	120	120
Above 11000 – maximum 15000	160	160

1) Intermediate values with corresponding distances are accepted.

Table 4.3: Alternative impulse voltage type test

Rated voltage [kV]	Highest voltage for equipment [kV]	Rated lightning impulse withstand voltage [kV]
3.0 3.3	3.6	40
6.0 6.6	7.2	60
10.0 11.0	12.0	75
15.0	17.5	95

Table 4.4: Minimum creepage distances for high voltage main switchboards and generators

Nominal voltage of the system, (V) 1)	Minimum creepage distance (for tracking index 300) (mm)			
	300 V	375 V	500	> 600 V
1000-1100	26 2)	24 2)	220 2)	20 2)
3 000-3300	63	59	53	48
6 000-6 600	113	108	99	90
10 000-11000	183	175	162	150

1) Intermediate values with corresponding distances are accepted.

2) Minimum 35 mm is required for busbars and other bare conductors in main switchboards.

Table 4.5: Minimum creepage distances for other high voltage equipment

Nominal voltage of the system, (V) 1)	Minimum creepage distance (for tracking index 300) (mm)			
	300 V	375 V	500	> 600 V
1000-1100	18	17	15	14
3 000-3300	42	41	38	36
6 000-6 600	83	80	75	70
10 000-11000	146	140	130	120

1) Intermediate values with corresponding distances are accepted.

5 Marking and Signboards

5.1 General

5.1.1 General

a) All equipment shall be externally marked to enable identification in accordance with the documentation of the power distribution system, and be marked with the manufacturer's name. In addition the system voltage shall be indicated on switchgear and assemblies.

b) All equipment shall if necessary be marked to ensure correct use.

c) See Sec.11 for the requirements for the marking of hazardous area equipment.

d) All marking shall be permanently fixed.

e) Labels bearing clear and indelible indications shall be so placed that all components and all equipment can be easily identified.

5.1.2 Rating plate

All equipment shall be fitted with a rating plate giving information on make, type, current, voltage and power rating and other necessary data for the application.

More detailed requirements for information noted on rating plates may be found in other applicable sections regarding each equipment type contained in this chapter (Sec.4 to Sec.9).

5.1.3 Labels for switchgear, terminals, cables.

a) Internal components in equipment and assemblies as switchgear, control gear, fuse gear, socket outlets, lighting equipment and heating equipment shall be marked with make, type, current, voltage and power rating and other necessary data for the application (i.e. to which standard the equipment is produced).

b) The switchgear and fuse gear for each circuit shall be marked with circuit designation, cable cross-section and rating of fuses or necessary data for easy recognition of components and circuits according to relevant drawings.

c) If the switchboard contains two or more distribution systems with different voltages, the different parts shall be marked with the respective voltages at the partitions.

d) Terminals for circuits with different system voltages shall be clearly separated, and clearly marked with the voltage.

e) All terminals for connection of external instrumentation and control cables shall be marked.

f) External instrumentation and control cables shall be marked for identification inside the cabinet. Each core in a cable shall be marked in accordance with Sec.9/ 2.1.3. The identification marking used shall be reflected in the wiring diagram or schematics.

It is expected that the owner and the shipyard agree a mutually acceptable method of providing permanent identification marking.

5.1.4 Signboards and warnings

a) Each switchgear fed from more than one individually protected circuit shall be marked with a warning sign stating that these circuits shall be isolated when the main circuit is isolated for maintenance purpose. A warning sign is not required if all live circuits within the enclosure are disconnected together with the main power circuit.

b) When, for fuses above 500 V, the fuse holders permit the insertion of fuses for lower nominal voltage, special warning labels shall be placed, for example “Caution, 660 V fuses only”.

c) Special “high voltage” warning signboards are required on all high voltage machines, transformers, cables, switch- and control gear assemblies.

6 Insulation

6.1 Insulation materials

6.1.1 General

a) Insulating materials, general purpose type, for supporting conductors (not defined as for machines and cables) shall withstand the temperatures to which they are likely to be exposed. This is normally ambient temperature plus the heat from the conductor itself during full load.

b) A thermal classification in accordance with IEC 60085 shall be assigned to the insulation system when used in machines. The normally used classes are shown in Table 6.1, with the maximum exposure temperatures (including ambient) shown in the right column.

c) Insulating materials shall be at least flame retardant. For cables see requirements in Sec.9.

d) Insulating materials shall be tracking resistant in accordance with IEC 60112. A tracking index of at least 175 V will be required for low voltage equipment. For high voltage equipment the tracking index shall be minimum 300 V. See Guidance note and Sec.13 regarding tracking index.

Table 6.1: General insulation classes

Insulation class (thermal class)	Maximum temperature °C
A	105
B	130
E	75
F	155
H	180
220	220

Section 4 Switchgear and Control Gear Assemblies

1 Construction

1.1 General

1.1.1 Applicable standards

a) Switchgear and control gear assemblies shall generally comply with IEC 61439-1 and IEC 60092-302 for low voltage equipment, and IEC 62271-200 for high voltage equipment.

b) Electronic equipment used in switchgear shall comply with environmental requirements given in Ch.3, Sec.5.

1.1.2 General

a) All switchboards and assemblies shall be safe against accidental touching of live conductors during normal operation of the switchboard or assemblies. (Interpretation of SOLAS Ch. II-1/45.2)

b) A low voltage switchboard or assembly shall be designed to withstand the short circuit forces for minimum 1 s, created by the short circuit current and magnitude at the particular point of the system without endangering the integrity of the outer switchboard enclosure. For high voltage equipment or assemblies, see 2.2.1.

c) For switchgear constructed and type tested in accordance with IEC 61439-1 sections can be designed to withstand the short-circuit stress occurring on the load side of the respective short-circuit protective device as stated in IEC 61439-1 item 7.5.5.1.2. However, this reduced short-circuit level shall not be less than 60% of the short circuit rating of the main busbars.

1.1.3 Accessibility

a) Instruments, handles, push buttons or other devices that should be accessible for normal operation shall be located on the front of switchboards and control gear.

b) All other parts that might require operation shall be accessible. If placed behind doors, the interior front shall comply with enclosure type IP 20. When located in spaces accessible to non-qualified personnel, fuses with accessible current-carrying parts may be permitted, if the door is lockable. Operation in this context means for example reset of protective devices and replacement of control circuit fuses inside the assembly.

c) Doors, behind which equipment requiring operation is placed, shall be hinged.

d) Hinged doors, which shall be opened for operation of equipment, shall be provided with easily operated handles or similar. There is also to be arrangements for keeping the doors in open position.

e) All sections of switchboards and control gear that require maintenance shall be accessible for maintenance work.

If the construction does not allow periodical maintenance, the assembly may be designed for maintenance free operation during a 20-year service life.

1.1.4 Materials

Framework, panels and doors are normally to be of steel or aluminium alloy, and shall be of rigid construction.

Switchgear and assemblies constructed of other materials may be accepted provided requirements in Sec.3 are complied with.

1.1.5 Circuit separation

a) There shall be arranged a separate cubicle for each generator, with flame retardant partitions between the different generator cubicles and between these and other cubicles. The partitions shall withstand the effect of an internal arc, and prohibit this from spreading to other cubicles.

b) Control gear for essential or important consumers shall be separated from each other, and from other current carrying parts, by flame retardant partitions providing protection of the cubicle in case of an arcing fault occurring in the neighbouring cubicle. Alternatively, an arrangement without flame retardant partitions may be accepted, provided the busbar is divided with a circuit breaker with short circuit protection, located in a separate cubicle.

The arrangement shall be so that maintenance work can be carried out in each unit without danger when isolated.

c) Control gear for non-important consumers may be installed in a common cubicle provided this cubicle could be effectively isolated.

d) Consumer control gear installed in main switchboards shall be placed in cubicles separated from all other parts of the switchboard by partitions of flame retardant material.

e) Equipment for different distribution systems shall be placed in separate switchboards (panels), or shall be separated from each other by partitions clearly marked with the actual voltages and system identifications.

f) Switchgear and control gear assemblies supplied by different supply circuits shall not be placed in the same enclosure.

g) For separation due to system redundancy, see Sec.2.

h) Equipment with voltage above 1 kV shall not be installed in the same enclosure as low voltage equipment, unless segregation or other suitable measures are taken to ensure that access to low voltage equipment is obtained without danger. (IACS UR E11.2)

i) Each outgoing circuit from a switchboard shall be provided with switchgear for isolating purposes in accordance with 2.1.5. If remote from the consumer, the switchgear shall be lockable in the “off” position.

For isolating purposes, a group of non-important consumers may be fed from one common switchgear.

j) On a distribution board this multipole switch may be omitted when maximum 63 A fuses are used.

Switching off by an auxiliary circuit will be accepted provided that the off–control switch is placed in front of the relevant compartment and a manual off-switching means is provided when front door is opened.

1.1.6 Handrails

Main and emergency switchboards and other switchboards requiring operation shall have handrails with an insulating surface.

1.1.7 Nameplates and marking

a) Switchgear and control gear assemblies shall be marked in accordance with general requirements given in Sec.3/ 4.

b) Protection devices shall be permanently marked with voltage, current and breaking capabilities.

c) Protection devices with adjustable settings shall have means that readily identify the actual setting of the protective device.

d) Circuit designation for outgoing circuits and incoming feeders shall be marked for identification.

e) The appropriate setting of overload protective device for each circuit shall be permanently indicated at the location of the protective device. (Interpretation of SOLAS Reg. II-1/45.6.2)

A document placed inside that assembly with the data required in d) and e) will be accepted.

1.1.8 “Type tested assemblies” and “Partly type tested assemblies”

a) Electrical low voltage assemblies constructed and tested in accordance with IEC 60092-302, item 7.1.2.101 (referring to IEC 61439-1) are accepted as long as the following conditions are met:

- minimum clearance distance shall be 8 mm, minimum creepage distance shall be 16 mm
- the assembly has been type tested with impulse voltage test in accordance with IEC 61439-1
- maximum operating temperature of busbars shall be documented to be acceptable with respect to fixing materials and internal temperature by a full current type test
- maximum temperature rise at termination points for external cables shall be 60ºC
- such assemblies shall not be installed in machinery space category “A”.

b) For busbar trunking systems where the conductors are fixed for the whole length with an insulating rail or similar, distances in accordance with IEC 61439-1 Table 14 and 16, pollution degree 3, inhomogeneous field, may be accepted.

2 Power Circuits

2.1 Power components in assemblies

2.1.1 Main busbar sectioning

See Sec.2 for requirements regarding main busbar division arrangement.

2.1.2 Busbar materials

a) Busbars and other conductors shall normally be made of copper or copper covered aluminium.

b) Copper coated aluminium or pure aluminium busbar shall be adequately protected against corrosion by placing in an air conditioned environment, by special coating sealing of the aluminium or by the aluminium itself being seawater resistant.

2.1.3 Rating of busbars

a) The shape, configuration and cross-section shall be such that the temperature rise will not exceed 45°C at rated load.

b) Busbars and other conductors with their supports shall be so mechanically or thermally dimensioned and fixed that they can withstand for 1 s the forces occurring by the maximum short circuit current which can occur without detrimental effect.

c) The cross-section of busbars for neutral connection on an AC three-phase, four-wire system, and for equaliser connection on a DC system, shall be at least 50% of the cross-section for the corresponding phases (poles).

d) For maximum temperatures of busbars in type tested and partially type tested assemblies the requirement in 1.1.8 applies.

e) The maximum permissible load for copper busbars with ambient temperature 45°C is given in Table 2.1.

f) Rating of aluminium busbar to be documented by type test report.

2.1.4 Fuses

Fuses shall normally comply with one of the following standards:

- IEC 60269 for low voltage fuses
- IEC 60282-1 for high voltage fuses.

2.1.5 Circuit breakers, on-load switches, disconnectors, and contactors

a) Switchgear and control gear shall be rated as required by Sec.2/ 7.2.2, and comply with:

- IEC 60947 for low voltage equipment
- IEC 60470, IEC 62271-100, IEC 62271-102 for high voltage equipment.

b) All fault switching and protecting components such as circuit breakers and fuses shall have a fault current withstand and interruption capacity of not less than the maximum short circuit current at the relevant point of their installation.

c) All load switches and contactors shall have a rating not less than the maximum load current at their point of installation. Particularly, contactors shall be protected against the possibility of the contactor breaking current exceeding their load break capacity in fault situations.

d) Fuse switches using the fuse element as making and breaking contacts are not accepted in place of switches, where such are required. Fuse switches may be accepted as isolating switches.

e) The construction shall be such that accidental making or breaking, caused by the vessel's inclination, movements, vibrations and shocks, cannot occur.

f) Under-voltage and closing coils, including contactor coils, shall allow closing of the switchgear and control gear when the voltage and frequency are 85 to 110% of nominal value. The under-voltage protection shall release if the voltage is below 70% or absolutely below 35% of nominal voltage.

g) Each circuit-breaker rated more than 16 A shall be of trip-free type, i.e. the breaking action initiated by short-circuit and overcurrent relays, or by under-voltage coil, when fitted, shall be fulfilled independently of the position or operation of manual handle or of other closing devices.

Table 2.1: Rating of copper busbars

Width x thickness (mm)	*Maximum permissible loading [A] with 50/60 Hz*							
	Painted (matt-black)				*Bare*			
	Numbers of bars				*Numbers of bars*			
	1 |	2 ||	3 |||	4 ||||	1 |	2 ||	3 |||	4 ||||
15 x 3	230	390	470	-	200	350	445	-
20 x 3	290	485	560	-	250	430	535	-
20 x 5	395	690	900	-	340	620	855	-
20 x 10	615	1145	1635	-	530	1020	1460	-
25 x 3	355	580	650	-	300	510	615	-
25 x 5	475	820	1040	-	405	725	985	-
30 x 3	415	670	735	-	350	590	700	-
30 x 5	555	940	1170	-	470	830	1110	-
30 x 10	835	1485	2070	-	710	1310	1835	-
40 x 5	710	1180	1410	-	595	1035	1350	-
40 x 10	1050	1820	2480	3195	885	1600	2195	2825
50 x 5	860	1410	1645	2490	720	1230	1560	2380
50 x 10	1260	2130	2875	3655	1055	1870	2530	3220
60 x 5	1020	1645	1870	2860	850	1425	1785	2740
60 x 10	1460	2430	3235	4075	1220	2130	2850	3595
80 x 5	1320	2080	2265	3505	1095	1795	2170	3370
80 x 10	1860	2985	3930	4870	1535	2615	3460	4275
100 x 10	2240	3530	4610	5615	1845	3075	4040	4935
120 x 10	2615	4060	5290	6360	2155	3545	4635	5580

Note: The current rating is based on 45°C ambient air temperature. Sufficient ventilation must be ensured, or the loading values shall be reduced.

2.1.6 Internal wiring

a) Connections to/from busbars to the short circuit protection shall be installed short-circuit proof, as defined in Sec.13. This requirement also applies to branching off for control power and measuring signals from busbars and generator terminals.

b) Interconnection between busbars shall be short circuit protected according to Sec.2/ 7.2.1, if the length of the cable/wire/flexible busbar exceeds 3 m.

c) Switchboard wires shall as a minimum be insulated single core wires unless used in a short circuit proof installation requiring double insulating wires or conductors.

In distributions boards where the connections mentioned in a) are sufficiently protected by upstream short circuit protection devices, the required short circuit proof installation may be exempted.

2.1.7 Screening of horizontally installed busbars

Horizontally installed busbars and bare conductors or connections shall be protected by screens, if they are placed such that there could be a risk of anything falling down on them.

2.1.8 Clearance and creepage distances

See Sec.3/ 4.6 for clearance and creepage distances in switchgear and assemblies.

2.2 Additional requirements for high voltage assemblies

2.2.1 General design and construction

a) High voltage switchgear and control gear assemblies shall be metal-clad in accordance with IEC 62271- 200, or of a construction giving equivalent safety with respect to personnel safety and system integrity. The switchgear shall able to withstand an internal short circuit arcing failure with the maximum duration and magnitude, which can occur on the particular point of the installation without harmful effect to operators.

b) The switchgear or switchboard shall be type tested to demonstrate that it will withstand the effects of an internal arc failure (e.g. testing in accordance with Appendix A of IEC 62271-200 Type A, Accessibility A with arcing time 1 s unless pressure relief flaps have been proven effective. Then arcing time as low as 0.1 s is accepted).

Accessibility A implies access only by instructed personnel, and that safe operation only is in front of the switchboard.

c) There shall be separate compartments with IP rating to at least IP 20 towards other compartments in the cubicle for at least the following components:

- control and auxiliary devices
- each main switching device
- components connected to one side of the main switching device (the outgoing circuit)
- components connected to the other side of the main switching device (the busbars).

d) Normally, partitions between the compartments shall be made of metal. Alternatively, a partition of other materials not intended to be earthed is accepted, provided it is verified that the safety is of at least the same standard.

If the main high-voltage switchgear is subdivided into two independent and autonomous installations, a continuous busbar compartment is permissible, provided that a protection system (arc monitor, busbar differential protection) is installed which detects internal faults and isolates the affected part of the installation within 100 ms, respectively accidental arcing is reliable prevented by design measures (e.g. solid insulated busbar systems).

e) Means shall be provided for the disconnection and isolation of all circuit breakers and fused circuit breakers, either by using withdrawable components or by installation of separate disconnectors (isolators).

Exception:

For final feeder circuits where energising of the main switching device from the load side is not possible, the cable terminals and accessories (e.g. voltage and current transformers) may be placed in the same compartment as the main switching device.

2.2.2 Mechanical interlocks

a) The arrangement in high voltage enclosures shall be such that all operation and functional testing is safeguarded against accidental touching of live parts.

b) Doors that can be opened for operation or testing of high voltage parts (e.g. for replacement of fuses, or for functional testing of a circuit breaker) shall be interlocked so that they cannot be opened before the components inside have been isolated and made safe.

c) The openings between the contacts of a withdrawable high voltage component and the fixed contacts, to which it is connected in service, shall be provided with automatic shutters.

Front doors of circuit breaker compartments might be opened for circuit breaker checking or emergency switching, without any interlocking, if high voltage parts still cannot be reached by accidental touching of the hands.

2.2.3 Control wiring

a) The wiring of auxiliary circuits shall, with the exception of short lengths of wire at terminals of instrument transformers, tripping coils, auxiliary contacts etc., be either segregated from the main circuit by earthed metallic partitions (e.g. metallic tubes) or separated by partitions (e.g. tubes or sheathed cables) made of flame retardant insulating material.

b) Fuses of auxiliary circuits, terminals and other auxiliary apparatus requiring access while the equipment is in service, shall be accessible without exposing high voltage parts.

c) An alarm shall be arranged for voltage loss after the last fuses in each auxiliary power system, where a voltage failure is not self detecting.

d) A possibility for manual operation of each circuit breaker shall be arranged. However, manual closing of the circuit breakers shall not be possible if the arrangement of the auxiliary circuits is such that the protection devices are put out of action and the circuit breakers are still closed after a power failure to the auxiliary circuits.

2.2.4 Safety earthing of high voltage circuits

Each circuit shall be fitted with an integral means of earthing and short circuiting for maintenance purposes, or alternatively an adequate number of portable earthing and short circuiting devices, suitable for use on the equipment in question, shall be kept on board.

3 Control and Protection Circuits

3.1 Control and instrumentation

3.1.1 General

a) Requirements for power supply and distribution of control circuits are given in Sec.2/ 8.2.

b) For short circuit proof installation of control cables, see 2.1.8.

3.1.2 Control of duplicated consumers

a) Control circuits for duplicated essential and important equipment shall be kept separated from each other, and not located in the same enclosure.

b) Control gear for duplicated essential or important equipment shall be mutually independent and shall be divided between two motor control centres or distribution boards having separate supplies from different sides of the main switchboard and/or the emergency switchboard.

c) Where switchboards are fitted with bus ties or bus links, the duplicated circuits shall be fed from different side of the bus tie.

d) Duplicated equipment for essential or important functions shall not be dependent on any common circuits such as e.g. contactors for emergency stop.

3.1.3 Signal lamps

Incandescent signal lamps shall be arranged so that a lamp short circuit cannot jeopardise the control system.

3.1.4 Panel-instruments in general

a) Instruments, including current transformers, in switchgear and control gear shall have a nominal accuracy of 2.5% or better.

b) The upper limit of the scale of ampere-meters and kilowatt-meters shall be at least 130% of the rated full load of the circuit. For generators arranged for parallel operation, the scale shall be arranged for reading of reverse current or power corresponding to at least 15% of the rated full load of the circuit. The upper limit of the scale of each voltmeter shall be at least 120% of the nominal voltage.

c) Ampere-meters, kilowatt-meters and voltmeters shall be provided with means to indicate rated current or power and rated voltage, respectively. Instruments shall have effective screening (e.g. by metal enclosures) in order to diminish faulty readings caused by induction from adjacent current-carrying parts.

d) Frequency meters shall be able to indicate values within a ranging at least 8% below and above the nominal frequency.

3.1.5 Generator instrumentation and control

a) Each generator cubicle shall as far as possible function independently as required in Sec.2/8.3. The wiring of each generator circuit breaker's control and release circuits (e.g. under-voltage circuit) is generally to be kept within its cubicle. Exemption: shunt-operated circuits for closing/opening of the circuit-breaker may be carried out e.g. to a common control panel.

b) Each AC generator shall be provided with instrumentation as listed in Sec.2/ 8.3.3

Instrumentation for current, voltage and frequency shall be arranged for simultaneous and continuous reading.

c) When generators are arranged for parallel operation, they shall in addition be provided with synchronizing devices as required by Sec.2/ 8.3.3.

d) Simultaneous functional reading of current and active power shall be provided at operating station for manual operation and synchronization.

Alternatives

Single voltmeters and ampere-meters with switches for the alternative readings may be accepted.

Two separate frequency meters for several generators may be used, one with a change-over switch for connection to all generators, the other connected to the busbars. A "double frequency meter" may be used for this purpose.

3.1.6 Instrumentation for distribution systems including in and outgoing circuits of switchboards

Each secondary distribution system shall be equipped with a voltmeter.

3.1.7 Instrumentation for shore connections

The shore connection circuit shall be equipped with:

- a phase sequence indicator
- a voltmeter or signal lamp.

4 Inspection and Testing

4.1 General

4.1.1 Factory testing

a) Switchgear and control gear assemblies shall be tested at the manufacturer's works as described in 4.1.2 to 4.1.8.

b) The manufacturer shall submit test results together with the final documentation for the equipment. The documentation shall give information on make, type, serial no., and all technical data necessary for the application of the switchboard or assembly, as well as the results of the required tests.

c) The following tests are required:

- function test: all basic functions, including auxiliary functions, shall be tested
- insulation resistance test
- high voltage test.

4.1.2 Visual inspection

Switchboards and assemblies are subject to a visual inspection for verification of general workmanship, creepage and clearance distances, IP rating, ventilation and quality of materials and components.

4.1.3 Function testing

a) All circuits shall be verified installed as shown in the as-build documentation.

b) Control and protection shall be tested for correct functioning.

Factory testing of switchgear or control gear assemblies at full power is normally not required.

4.1.4 Onboard testing

Switchgear or control gear assemblies shall be subject to complete function tests after installation onboard. See Sec.10/ 4.

4.1.5 Power frequency and insulation resistance test for low voltage assemblies

a) Switchgear and assemblies with rated voltage above 60 V shall be subject to a voltage test between the circuits and between live parts and the enclosure. The test voltage shall be minimum equal to twice the rated voltage plus 1 000 V with a minimum of 1 500 V. The test voltage shall be applied for 1 minute at any frequency between 25 and 100 Hz.

b) For switchgear and assemblies with rated voltage below 60 V, the test voltage given in a) shall be minimum 500 V.

c) As an alternative to the voltage test in a), impulse voltage test in accordance with IEC 61439-1 Section 8.3.2 can be carried out for type tested (TT) and partly type tested (PTT) low voltage assemblies

d) Insulation resistance shall be measured prior to and on completion of the voltage test. Insulation resistance test voltages and acceptance values are given in Sec.5 Table 3.3. It shall be verified that the voltage testing does not cause any reduction in switchgear insulation level. The insulation level shall be at least 1 MOhm.

Electronic equipment should be disconnected, short circuited and or isolated during high voltage test and insulation resistance measuring.

The secondary winding of current transformers shall be short circuited and disconnected from earth during the test.

The secondary winding of voltage transformers shall be disconnected during the test.

4.1.6 Power frequency test for high voltage assemblies

a) Each high voltage assembly shall be subjected to a 1 minute power frequency voltage test.

b) Replicas reproducing the field configuration of the high voltage connections may replace voltage transformers or power transformers. Overvoltage protective devices may be disconnected or removed.

c) Test voltages are given in Table 4.1.

d) Insulation resistance shall be measured prior to and on completion of the voltage test. Insulation resistance test voltages and acceptance values are given in Sec.5 Table 3.3. It shall be verified that the voltage testing does not cause any reduction in switchgear insulation level.

e) All auxiliary circuits shall be subjected to a 1 minute voltage test between the circuits and the enclosure according to 4.1.5.

The environmental conditions during voltage tests are normally to be as specified in IEC 60060-1, "High-voltage test techniques, Part 1, General definitions and test requirements", that is temperature 20°C, pressure 1013 mbar and humidity 11 g water per m^3 (corresponding to about 60% relative humidity). Correction factors for test voltages at other environmental conditions are given in IEC 60060-1.

Table 4.1: Test voltages for high voltage assemblies

Nominal voltage of the system (kV) 1)	1 minute power frequency test voltage, (kV) (root mean square value)
	To earth and between phases
1 - 1.1	2.8
3 - 3.3	10
6 - 6.6	20
10 - 11	28
15	38

1) Intermediate values for test voltages may be accepted, other than these standard test voltages.

Section 5 Rotating Machines

1 General

1.1 References

1.1.1 General

The design and function of rotating machines shall generally comply with the requirements of IEC 60092-301.

For basic machine design, the relevant parts of IEC 60034 apply.

1.2 Requirements common to generators and motors

1.2.1 Rating

a) Electrical machines, including any excitation system, shall be designed for continuous duty unless otherwise clearly stated.

b) Generally, maximum environmental temperatures for rotating machines shall be as given in Sec.3 Table 2.1.

1.2.2 Insulation

a) All windings for machines shall be treated to resist moisture, sea air, and oil vapours.

b) For general requirements for insulation materials and terminations, see Sec.3 /4.

1.2.3 Temperature rise in windings (insulation)

The maximum permissible temperature rise in windings is given in Table 1.1, with the following exceptions:

a) If the temperature of the cooling medium will be permanently lower than the values given in Sec.3/ 2.3, then the permissible temperature rise may be increased with the difference between the actual temperature and the temperature given in Sec.3/ 2.3. Maximum acceptable increase is 20°C.

b) If the ambient temperatures clearly exceed the maximum upper limits, then the temperature rises shall be decreased accordingly.

c) In Table 1.1 allowance has been made for the temperature in certain parts of the machine being higher than measured. The temperatures at such “hot spots” are assumed not to exceed the values given in Sec.3 Table 6.1.

d) For vessels with class notation restricting the service to non-tropical waters the design limits for temperature rises given in Table 1.1 may be increased by 10°C. Alternatively, the upper ambient air temperature limits according to Table 1.1 may be reduced by 10°C.

e) Where water cooled heat exchangers are used in the machine cooling circuit, the temperature rise shall be measured with respect to the temperature of the cooling water at the inlet to the heat exchanger.

Temperature rises given in Table 1.1 may be increased by 13°C provided the inlet water does not exceed 32°C.

f) If inlet water temperature is above 32°C, permissible temperature rise in Table 1.1 may be increased by 13oC and then reduced by the amount by which the maximum cooling water temperature exceeds 32°C.

g) If the inlet cooling water temperature is permanently less than 32°C, the permissible temperature rise in Table 1.1 may be increased by 13°C and may be further increased by an amount not exceeding the amount by which the cooling temperature is less than 32°C.

h) For machines with insulating class 220 the temperature rise will be evaluated in each case.

Table 1.1: Limits of temperature rise of machines for vessels for unrestricted service based on ambient temperature of 45°C

Part of machine [1)]		Method of measurement of temperature [2)]	Maximum temperature rise in for air-cooled machines (ºC) Insulation class				
			A	E	B	F	H
1	a) AC winding of machine having output of 5000 kVA or more	ETD R	60 55	-[3)] -	80 75	105 100	125 120
	b) AC winding of machine having output of less than 5 000 Kva	ETD R	60 55	- 70	80 75	105 100	125 120
2	Winding of armature with commutators	R T	55 45	70 60	75 65	100 80	120 100
3	Field winding of AC and DC machine with excitation other than those in item 4.	R T	55 45	70 60	75 65	100 80	120 100
4	a) Field windings of synchronous machines with cylindrical rotors having DC excitation	R			85	105	130
	b) Stationary field windings of DC machines having more than one layer	ETD R T	55 45	70 60	85 75 65	105 100 80	130 120 100
	c) Low resistance field windings of AC and DC machines and compensating windings of DC machines having more than one layer	R T	55	70	75	95	120
	d) Single-layer windings of AC and DC machines with exposed bare surfaces or varnished metal surfaces and single compensating windings of DC machines	R T	60	75	85	105	130

1) Temperature rise of any part of a machine shall in no case reach such a value that there is a risk of injury to any insulating or other material in adjacent parts.

2) R indicates temperature measurement by the resistance method, T the thermometer method and ETD the embedded temperature detector method. In general for measuring the temperature of the windings of a machine the resistance method shall be applied. (See IEC 60034-1). For stator windings of machines having a rated output of 5 000 kW (or kVA) the ETD method shall be used. Determination by ETD method requires not less than six detectors suitably distributed throughout the winding. Highest reading shall be used to determine the temperature for the winding.

3) For high voltage machines having rated output of 5 000 kVA or more, or having a core length of 1 m or more, the maximum temperature rise for class E insulation shall be decreased by 5ºC.

1.2.4 Machine short time overloads

a) General purpose rotating machines shall be designed to withstand the following excess torque:

- AC induction motors and DC motors: 60% in excess of the torque that corresponds to the rating, for 15 s, without stalling or abrupt change in speed (under gradual increase of torque), the voltage and frequency being maintained at their rated value
- AC synchronous motors with salient poles: 50% in excess of the torque that corresponds to the rating, for 15 s, without falling out of synchronism, the voltage, frequency and excitation current being maintained at their rated values
- AC synchronous motors with wound (induction) or cylindrical rotors: 35% in excess of the torque that corresponds to the rating, for 15 s, without losing synchronism, the voltage and frequency being maintained at their rated value.

b) Induction motors for specific applications the excess torque may be subject to special agreement. See IEC 60034-1 clause 9.3.

c) General purpose rotating machines shall be designed to withstand the following excess current:

- AC generators: 50% in excess of the rated current for not less than 30 s, the voltage and frequency being maintained as near the rated values as possible
- AC motors: 50% in excess of the rated current for not less than 120 s, the voltage and frequency being maintained as near the rated values as possible
- commutator machines: 50% in excess of the rated current for not less than 60 s, operating at highest full-field speed.

1.2.5 Balance

Machines shall be so constructed that, when running at any and every working speed, all revolving parts are well balanced.

1.2.6 Lubrication

a) Lubrication of rotating machines shall be effective under all operating conditions.

b) Each self-lubricated sleeve bearings shall be fitted with an inspection lid and means for visual indication of oil level or use of an oil gauge. Similar requirement applies to self contained oil lubricated roller bearings.

c) Provision shall be made for preventing the lubricant from gaining access to windings or other insulated or bare current-carrying parts.

1.2.7 Shafts and shaft currents

a) Shafts shall comply with the requirements in Ch.1, Sec.10 both with regard to strength, bearings and balancing.

b) Means shall be provided to prevent damaging levels of circulating currents between shaft, bearings and connected machinery.

c) When all bearings on a machine are insulated, the shaft shall be electrically connected to the machine's earth terminal.

1.2.8 Machine overspeed

Rotating machines shall be capable of withstanding 1.2 times the rated maximum speed for a period of 2 minutes.

1.2.9 Nameplate

Each machine shall be provided with nameplate of durable material, giving the following information:

- make, type, serial no.
- performance standard
- IP rating
- rated values for: output apparent power, voltage(s), frequency, current(s), power factor, speed
- for AC machines: the winding connection
- thermal classification of insulation
- duty type
- maximum permissible cooling medium temperature
- technical data necessary for the application of the machine
- total mass.

1.3 Instrumentation of machines

1.3.1 Temperature detectors embedded in stator winding

Low voltage machines having a rated output above 5 000 kW (or kVA), and all high voltage machines shall be provided with temperature detectors in their stator windings, for monitoring and alarm, also see Sec.3/ 4.2.1.

Overvoltage protection may be required for circuits with temperature detectors.

See Sec.12/ 1.6.4 regarding rotating machines supplying or driving electric propulsion and having temperature detectors embedded in their stator windings for monitoring and alarm.

For the requirements in regard to temperature detectors, reference is made to IEC 60034-11.

2 Additional Requirements for Generators

2.1 General

2.1.1 General

Exciter and voltage regulation equipment is considered as part of the generator.

2.1.2 Automatic voltage regulator

The AVR shall be capable of keeping the voltage within the values specified for stationary and dynamic variations.

2.1.3 Available neutral point

Generators with rating exceeding 1500 kVA, and all high voltage generators, shall be prepared for installation of equipment for short circuit protection of the generator windings.

2.1.4 De-excitation

Generators with rating exceeding 1500 kVA, and all high voltage generators, shall be prepared for external signal for initiation of de-excitation of the generator.

2.1.5 Voltage waveform

For AC generators, the voltage shall be approximately sinusoidal, with a maximum deviation from the sinusoidal curve of 5% of the peak value.

2.2 Voltage and frequency regulation

2.2.1 Voltage build-up

a) The construction shall normally be such that the generator, when started up, takes up the voltage without the aid of an external electric power source.

b) External power sources may be used to take up the voltage on main generators provided that redundancy for this external source is arranged as required for starting arrangement.

2.2.2 Stationary voltage regulation

a) The voltage regulation shall be automatic, suitable for shipboard condition, and such that the voltage is kept within 97.5% to 102.5% of the rated voltage under all steady load conditions. This is between no-load and full-load current and at all power factors which can occur in normal use, but in any case with power factor from 0.7 to 0.9 lagging, also taken into consideration the effect of the prime mover's speed characteristic.

b) There shall be provision at the voltage regulator to adjust the generator no load voltage.

c) The limits in a) may be increased to ±3.5% for emergency sets.

2.2.3 Transient voltage regulation

a) Maximum values (current and power factor) of sudden loads to be switched on and off shall be specified.

Specified sudden load should not be less than 60% full load current at power factor of 0.4 lagging or less.

b) The voltage variations under transient conditions shall comply with the following:

- when the generator is running at no load, at nominal voltage, and the specified sudden load is switched on, the instantaneous voltage drop at the generator terminals shall not be more than 15% of the generators nominal voltage.

The generator voltage shall be restored to within ± 3% of the rated voltage within 1.5 s.

- when the specified sudden load is switched off, the instantaneous voltage rise shall not be more than 20% of the rated voltage.

The generator voltage shall be restored to within ± 3% of the rated voltage within 1.5 s.

c) For non-paralleling emergency generating sets the regulation limits and time in b) might be increased to ± 4% within 5 s.

d) On installations where two or more generators are normally run in parallel, the maximum load that can be switched on may be divided between the generators in relation to their rating and expected maximum duty as individual generator.

Special consideration should be given to the overvoltage that may occur when switching off the generators at full load or overload. This overvoltage should not reach a level that may damage power supplies for AVRs, under-voltage coils, instruments etc. connected on the generator side of the generator circuit breaker.

2.3 Generator short circuit capabilities

2.3.1 Short circuit withstand and contribution capabilities

AC synchronous generators, with their excitation systems, shall, under steady short circuit condition be capable of maintaining, without sustaining any damage, a short circuit current, which shall be at least 3 times the rated full load current, for a duration of at least 2 s. (IEC 60092-301 modified clause 4.2.3)

2.4 Parallel operation

2.4.1 Load sharing

a) Generators for parallel running shall be such that the sharing of active and reactive power is stable under all load conditions. Oscillations smaller than ±20% of each generator's rated current can be accepted.

b) In the range 20 to 100% of the rated reactive load of each generator, its actual reactive load (mean value, if oscillations occur) shall not differ from its proportionate share of the total reactive load by more than 10% of the rated reactive load of the largest generator in parallel, or not more than 25% of the smallest generator's rated reactive load, if this is less than the former.

The sharing of power is mainly determined by the prime movers' governor characteristics. Power oscillations, however, are determined both by the prime movers' and generators' characteristics.

2.4.2 Parallel operation on nets with earthed neutral

When generators are run in parallel on nets with earthed neutral, it shall be ensured that the equalising current resulting from harmonics does not exceed 20% of the rated current of each generator.

3 Inspection and Testing

3.1 General

3.1.1 Factory testing

a) Electrical machines shall be tested at the manufacturer's works with the tests specified in this part of the rules. Type tests shall be carried out on a prototype of a machine or the first of a batch of machines. Routine tests shall be carried out on each machine.

b) The type tests (TT) and routine tests (RT) that the machines shall undergo are listed in Table 3.1

c) The tests in Table 3.1 shall be documented. The documentation shall give information on make, type, serial no., insulation class, all technical data necessary for the application of the machine, as well as the results of the required tests.

d) The result of type tests, and the serial number of the type tested machine, shall be specified

in the documentation of test results for routine tests.

Table 3.1: Testing and inspection of electrical machines

No.	Task	Required test for generators	Required test for motors
1	Examination of technical documentation. Air gap to be measured or verified.[1)]	TT, RT	TT, RT
2	Visual inspection, verification of data on name plate.	TT, RT	TT, RT
3	Verification of degree of enclosure protection (IP)	TT	TT
4	During the running tests, the vibration or balance of the machine including operation of the bearing or lubrication system. Reference: 60034-14	TT, RT	TT, RT
5	Overspeed test: 20% in excess of the rated r.p.m. for 2 minutes.	TT	TT [4)]
6	Withstand voltage test, 1 minute.	TT, RT	TT, RT
7	Winding's resistance to be measured.	TT, RT	TT, RT
8	Temperature-rise test at full load.	TT	TT
9	Measurement of insulation resistance.	TT, RT	TT, RT
10	No load current at rated voltage and frequency.		TT, RT
11	Overload or overcurrent test [3)] (IEC 60034-1/9.3 and 9.4).	TT	TT
12	AC generator: Measuring of voltage regulation during steady and transient loading and unloading, see 2.2.2 and 2.2.3	TT, RT [2)]	
13	AC generator: Measuring of open circuit voltage characteristics (no load curve).	TT, RT	
14	AC generator: Measuring of short circuit characteristics (short circuit curve).	TT, RT	
15	AC synchronous motor or generator: Measuring of excitation current at rated voltage, current and power factor.	TT, RT	TT, RT
16	AC Synchronous generator: Measuring of steady short circuit condition.	TT	
17	For high voltage machines a steep fronted impulse test, or equivalent, of the coil interturn insulation shall be carried out according to IEC 60034-15.Tests on each separate fully processed coil after inserting in the slots are preferred. Due to various technologies involved, alternative proposals to verify withstand level of interturn insulation may be considered, e.g. type tests with fully produced sample coils.	RT	RT

1) Measuring of air gap only for machines of size 1.5 MVA and above.

2) Only functional test of voltage regulator system.

3) Overload test for generators. Test of momentary excess torque for motors.

4) Except for squirrel cage motors

Overspeed test (5)

Dielectric test to be performed on rotors after overspeed test IEC 60034-1-9.7.

High voltage tests (6)

a) A 1 minute high voltage test should be applied to a new and completed machine with all its parts in place under conditions equivalent to normal working conditions. The test should be in accordance with IEC 60034-1-9.2 “Withstand voltage test”, and should be carried out at the maker's works at the conclusion of the temperature-rise test.

b) For voltage levels to be used, see IEC 60034-1 Table 16, normally (for ac windings of machines between 1 kW and 10 000 kW) the test voltage is 1 000 V + twice the rated voltage with a minimum of 1 500 V.

c) After rewinding or other extensive repair of a machine, it should be subjected to a high voltage test with a test voltage of at least 75% of that specified in IEC 60034-1-9.2.

d) On carrying out high-voltage test, it may be necessary to short circuit semi-conductors in order to avoid damage of such parts.

Temperature rise measurement and testing (8)

a) The temperature rise of a machine should be measured at the rated output, voltage and frequency, and the temperature test should be carried out at the duty for which the machine is rated and marked, in accordance with the testing methods specified in IEC Publication No. 60034-1.

b) For machines with maximum continuous rating, the temperature rise test should be continued until thermal equilibrium has been reached, that is when the temperature varies by not more than 2°C over a period of 1 h.

c) For acceptable methods of winding temperature measurement and corresponding maximum temperatures, see Table 1.1.

d) The measurement of final winding temperature at end of the test should be performed within the time limits given in Table 3.2.

e) If measurements of final winding temperature should be carried out by resistance measurements according to Table 3.2, the temperature shall be measured as a function of time after shutdown, and correct temperature being determined by extrapolation back to the initial switch off time point.

f) The initial reading shall not be delayed by more than twice the time limits given in Table C2. (See IEC 60034-1 8.6.2 for extended guidance on this subject).

Table 3.2: Resistance measurement time after switch off

Rated output, P(kW) (kVA)	Time delay after switching off power (s)
P ≤50	30
50 < P ≤200	90
200 < P ≤5000	120
5000 < P	By agreement

g) When the resistance method is used, the temperature for copper windings, θ1 - θ2, may be obtained from the ratio of the resistances by the formula:

$(\theta_2 + 235)/(\theta_1 + 235)= R_2 / R_1$

θ_2 = winding temperature at the end of the test

θ_1 = winding temperature at the moment of the initial resistance measurement.

The temperature rise is the difference between the winding temperature at the end of the test, and the ambient air temperature at the end of the test. (Alternatively the water inlet temperature at the end of the test, for water/air heat exchangers.)

The resistance of a machine winding should be measured and recorded using an appropriate bridge method or voltage and current method.

h) When the embedded temperature detector (ETD) method is used, there should be at least six detectors suitably distributed throughout the machine windings. They should be located at the various points at which the highest temperatures are likely to occur, and in such a manner that they are effectively protected from contact with the coolant. The highest reading of an ETD element should be used to determine compliance with requirements for temperature limits.

i) When there is two or more coil-sides per slot, the ETD elements should be placed between the insulated coil sides.

If there is only one coil-side per slot, the ETD method is not a recognized method for determination of temperature rise or temperature limits in order to verify the compliance of the rating.

j) The thermometer method is recognized in the cases in which neither the ETD method nor the resistance method is applicable. See IEC 60034-1 for guidance. The measured temperature rises should not exceed the following values:

65 K for class A insulation

80 K for class E insulation

90 K for class B insulation

115 K for class F insulation

140 K for class H insulation.

Alternative methods for temperature rise calculations

Temperature tests at full load may be difficult to realise for large machines, due to insufficient test power being available. One of the following simulated tests, or equivalent, will be subject for approval for synchronous generators and induction motors:

- synchronous feedback, or back to back method, according to IEEE Std. 115-1983, 6.2.2
- zero power factor method, according to IEEE Std. 115-1983, 6.2.3
- open-circuit and short circuit loading method, according to IEEE Std. 115-1983, 6.2.4
- "Equivalent loading and super-position techniques - Indirect testing to determine temperature rice.", according to IEC 61986.

Insulation resistance test (9)

a) The insulation resistance of a new, clean dry machine, should be measured immediately after the temperature test has been carried out and after high voltage test has been carried out using a direct current insulation tester between:

- all current carrying parts connected together and earth
- 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 voltage and insulation are given in Table 3.3. The temperature at which the resistance is measured should be near the operating temperature, or an appropriate method of calculation may be used.

b) On carrying out insulation resistance test, it may be necessary to short circuit semi-conductors in order to avoid damage to such parts.

Table 3.3: Minimum insulation resistance values

Rated voltage U_n (V)	Minimum test voltage (V)	Minimum insulation resistance (MΩ)
$Un \leq 250$	$2 \times U_n$	1
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	$(U_n / 1000) + 1$
$7200 < U_n \leq 15000$	5000	$(U_n / 1000) + 1$

Overload testing (11)

Overloads as stated in 1.2.4 are difficult to test on large machines. In case overloads cannot be tested, documentation or calculations based on manufacturers proven methods and experience will be accepted.

Alternative methods for measuring excitation current at rated voltage, current and power factor (15)

Temperature tests at full load may be difficult to realise for large machines, due to insufficient test power being available. One of the following simulated tests, or equivalent, will be subject for approval for synchronous generators and induction motors:

- load excitation, according to IEEE Std. 115-1983, 6.2.2.

3.1.2 Onboard testing

All machines shall be tested onboard, after installation, so that acceptable starting and running performance are verified with full capacity of driven equipment, alternatively full generator load. See Sec.10.

Section 6 Power Transformers

1 General

1.1 General

1.1.1 Reference

The design of transformers shall in general comply with the requirements of IEC 60092-303 and relevant parts of IEC 60076.

1.2 Design requirements for power transformers

1.2.1 General

a) Transformers shall be double wound. Starting transformers and transformers feeding single consumers, as long as the secondary consumer has the same insulation level as the primary side, may be of autotransformer type.

b) Normally, transformers shall be of the dry air-cooled type. Where forced cooling is used, it shall be possible to operate at reduced power on failure of a pump or a fan. Power transformers with forced cooling shall be equipped with monitoring and alarm as required by Sec.3/ 4.2.

c) All windings for air-cooled transformers shall be treated to resist moisture, sea air, and oil vapours.

d) For the general requirements for insulation materials and terminations, see Sec.3/ 4.

e) For requirements for busbar material see Sec.4/ 2.1.

1.2.2 Liquid immersed transformers

a) Liquid immersed transformers, filled with liquid with flashpoint above 60oC, may be accepted in engine rooms or similar spaces if provisions have been made, when installed, for containing or safe draining of a total liquid leakage.

b) Normally, liquid immersed transformers shall be of the sealed type. However, conservator type may be accepted if the construction is such that liquid is not spilled, when the transformer is inclined at 40°.

c) Liquid immersed conservator type transformers shall have a breathing device capable of stopping (trapping) moisture from entering into the insulating liquid.

d) Arrangement for containment of accidental leakage shall be arranged.

e) A liquid gauge indicating the normal liquid level range shall be fitted.

f) Liquid immersed transformers shall be provided with monitoring as required in Table 1.1.

Table 1.1: Monitoring of liquid immersed transformers

Item	Alarm	Load reduction or trip	Comments
Liquid level,low	X	X	
Liquid temperature, high	X	X	
Gas pressure, high		X	Trip
Interturn short circuit		X	Trip

1.2.3 Temperature rise

Temperature rise for transformers, above ambient, according to Sec.3/ 2.3, shall not exceed the following values (measured by the resistance method):

a) Dry type transformer windings:
- insulation class A: 55°C
- insulation class E: 70°C
- insulation class B: 75°C
- insulation class F: 95°C
- insulation class H: 120°C
- insulation class 220: 145°C

b) Liquid immersed transformers:
- temperature rise for windings: 55°C
- temperature rise for liquid when the liquid is in contact with air: 45°C
- temperature rise for liquid when the liquid not is in contact with air: 50°C.

1.2.4 Parallel operation

Transformers for parallel operation shall have compatible coupling groups and voltage regulation, so that the actual current of each transformer will not differ from its proportionate share of the total load by more than 10% of its full load current.

1.2.5 Voltage regulation

Transformers supplying secondary distribution systems for general use shall normally have a maximum 2.5% voltage drop from no load to full load at resistive load.

1.2.6 Short circuit withstand and protection

Transformers shall be constructed to withstand a primary or secondary terminal short circuit with a duration of minimum 1 s, with rated primary voltage and frequency, without damage to internal parts or enclosure.

1.2.7 Nameplate

Each power transformer shall be provided with nameplate of durable material, giving the following information:
- make, type, serial no.
- performance standard
- rated values for: output apparent power, voltage(s), frequency, current(s)
- duty type
- thermal classification of insulation
- IP code of enclosure and termination box

- vector group of windings
- maximum permissible cooling medium temperature
- short circuit impedance value
- liquid type (if applicable)
- total mass.

2 Inspection and Testing

2.1 General

2.1.1 Factory testing

a) Transformers shall be tested at the manufacturer's works with the tests specified in this part. Tests noted as type tests (TT) shall be carried out on a prototype or the first of a batch of identical transformers. Tests noted as routine tests (RT) shall be carried out on each transformer.

b) The tests shall be documented. The documentation shall give information on make, type, serial no., insulation class, all technical data necessary for the application of the transformer, as well as the results of the required tests.

c) The result of type tests, and the serial number of the type tested transformer, shall be specified in the documentation of test results for a routine test.

d) Required inspection and tests for distribution transformers are given in Table 2.1.

Table 2.1: Testing and inspection of transformers

No.	Task	Type of test	IEC reference
1	Inspection of enclosure, terminations, instrumentation or protection	RT	
2	Measuring of insulation resistance	RT	
3	Measuring of voltage ratio at no load and check of phase displacement	RT	IEC 60076-11.16
4	Measuring of winding resistance	RT	IEC 60076-11.15
5	Short circuit impedance and load losses	RT	IEC 60076-11.17
6	Measuring of no-load loss and current	RT	IEC 60076-11.18
7	Separate-source AC withstand voltage test	RT	IEC 60076-11.19
8	Inducted AC withstand voltage test	RT	IEC 60076-11.20
9	Temperature rise test	TT	IEC 60076-11.23
10	Partial discharge measurement on transformer windings above $U_m \geq 3.6$kV. Maximum level of partial discharge shall be 10 pC.	RT	IEC 60076-11.22

2.1.2 Temperature rise test

Temperature test at full load may be difficult to realise on large transformers, due to insufficient test power being available. One of these simulated tests, or equivalent may be accepted:

- back to back method, according to IEC 60076-11 23.2.2
- simulated load method, according to IEC 60076-11 23.2.1.

2.1.3 Separate-source AC withstand voltage test/ high voltage test

a) A high voltage test shall be applied to a new and completed transformers.

b) The test shall be carried out immediately after the temperature rise test, when such is required.

c) The test shall be applied between each winding and the other windings, frame and enclosure all connected together. The full test voltage shall be maintained for 1 minute. For test levels, see Table 2.2.

d) Single phase transformers for use in a polyphase group shall be tested in accordance with the requirements for the transformers as connected together in the system.

e) After rewinding or other extensive repair the transformer shall be subjected to a high voltage test with a test voltage of at least 75% of that specified in c) above.

2.1.4 Insulation resistance testing

The insulation resistance of a new, clean dry transformer shall be measured immediately after the temperature raise test, when such is required, and the high voltage test has been carried out. Test voltage and minimum insulation resistance is given in Table 2.3. The test shall be carried out between:

- all current carrying parts, connected together, and earth
- all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

2.1.5 Onboard testing

All transformers shall be subject to function tests with intended loading, after installation onboard.

Table 2.2: Test voltages

Highest voltage for equipment Um(kV r.m.s.)	Rated short duration power frequency withstand voltage (kV r.m.s)
≤ 1	3
3.6	10
7.2	20
12	28
17.5	38

Table 2.3 Test voltages and minimum insulation resistance

Rated voltage U_n (V)	Minimum test voltage (V)	Minimum insulation resistance (MΩ)
Un ≤ 250	2 x U_n	1
250 < U_n ≤ 1000	500	1
1000 < U_n ≤ 7200	1000	(U_n /1000) + 1
7200 < U_n ≤ 15000	5000	(U_n /1000) + 1

Section 7 Semi-Conductor Converters

1 General Requirements

1.1 General

1.1.1 References

a) The design and construction of semi-conductor converters shall comply with relevant requirements of Sec.3 and Sec.4. For control and monitoring equipment the requirements are given in Ch.3.

b) Voltage and frequency characteristics of supply networks are given in Sec.2/ 1.2.

c) The design of semi-conductor converters shall comply with the requirements of IEC 60146-1-1 with applicable requirements modified to suit marine installations like e.g. environmental requirements stated in Section3.

d) The design of semi-conductor converters for power supply shall in addition to a), b) and c) comply with the requirements of IEC 62040 series.

e) The design of semi-conductor converters for motor drives shall in addition to a) b) and c) comply with the requirements of IEC 61800 series.

Semi-conductor converters for power supply covers systems with converters with and without means for energy storage. UPS, battery chargers, clean power units etc.

References to specific clauses in IEC standards are based on valid editions per 2010.

1.1.2 Technical integration

Unless otherwise stated, it is the responsibility of the Yard to ensure technical integration of transformers, converters, motors and generators with respect to:

- Rating and cooling (with respect to increased losses)
- Torque/speed characteristics
- Acceleration/breaking
- Bearing currents
- Harmonic filters
- Operating philosophies
- Installation instructions.

1.1.3 Functionality

A converter shall be described in a functional description. This description shall at least cover the following items:

- Intended use and operational modes
- Control system
- Integration versus higher level control system
- Redundancy for cooling

- Manual operation
- Protection functions, trips and shut downs
- Redundancy
- Alarms
- Specific functional requirements given in applicable rules, e.g. Sec.12 for electric propulsion.

1.2 Design and construction requirements

1.2.1 Electrical rating and duty

a) The specified capacity shall at least include a 100% continuous load, and a specified overload capacity given by a current of maximum duration of time.

b) Converters for motor drives (including soft starters), shall as a minimum withstand two consecutive start attempts immediately followed after stopping, or starting up from cold without being overheated.

c) For battery chargers and UPS, requirements for charger capacity are given in Sec.2/ 4.1.2.

1.2.2 Creepage and clearance distances

Unless an impulse voltage test has been carried out as a type test with impulse voltages as given in relevant product standard, the creepage and clearance distances shall be in accordance with relevant product standard, suitable for pollution degree 3 and overvoltage category III. The clearance and creepage distances given in the relevant IEC standards are reproduced in Table 1.1 to 1.3. The impulse voltage test voltages are reproduced in table 2.3.

For semi-conductor converters for power supply the requirements are given in IEC 60950-1. For semi-conductor converters for motor drives the requirements are given in IEC 61800-5-1

Table 1.1: Minimum clearance distances for low voltage semi-conductor converters 1)

Nominal voltage of the system, (line voltage); (V) 2)	Minimum clearance distance, (mm)
120	0.80
220, 230, 240	1.5
380, 400, 415, 440, 480	3.0
600, 630, 660, 690	5.5

1) Extract from IEC 61800-5-1, Table 7, 8 and 9, and IEC 60950-1, Annex G, Table G.2. Applicable for three phase systems. If single phase supply, the distance shall be increased one step.

2) Interpolation is not permitted.

Table 1.2: Minimum clearance distances for high voltage semi-conductor converters 1)

Nominal voltage of the system (maximum line voltage); (V) 2)	Minimum clearance distance, (mm)
1732	8.0
6235	25
12470	60
20785	90

1) Extract from IEC 61800-5-1, Table 7, 8 and 9, and IEC 60950-1, Annex G, Table G.2.

2) Interpolation is permitted.

Table 1.3: Minimum creepage distances, semi-conductor converters 1)

Working voltage (V) 2) 3) (rms)	Minimum creepage distance 4), (mm)
100	2.2
160	2.5
200	3.2
250	4.0
320	5.0
400	6.3
500	8.0
630	10.0
800	12.5
1000	16
1250	20
1600	25
2000	32
2500	40
3200	50
4000	63
5000	80
6300	100
8000	125
10000	160

1) Extract from IEC 61800-5-1, Table 10, and IEC 60950-1, Table 2N.

2) The highest voltage to which the insulation under consideration is, or can be, subjected when the equipment is operating at its rated voltage under conditions of normal use.

3) Interpolation is permitted.

4) Based on insulating material group IIIa/b. If the material group is not known, group IIIa/b shall be assumed.

1.2.3 Capacitor discharge

Capacitors within a converter shall be discharged to less than 60 Volt in less than 5 s (or a residual charge of less than 50 μC) after removal of the power. If this requirement not is achievable, warning signboards shall be fitted.

1.2.4 Accessibility

Semi-conductor elements, fuses or other parts likely to be changed out, shall be so arranged that they can be removed from equipment without dismantling the complete unit.

1.2.5 Access conditions for high voltage converters

High voltage sections of converters shall have enclosures as required for high voltage switchgear in Section 4.

Doors shall be automatically locked unless the main circuit breaker is open and the circuit is earthed.

1.2.6 Cooling

a) Where forced cooling is provided, the apparatus is, unless otherwise particularly required, to be so arranged that the converter cannot remain loaded unless effective cooling is provided, or other effective means of protection against over temperature is provided. See also Sec.3/ 4.2.

b) Piping shall be arranged to prevent harmful effects due to leakage or condensation, and be installed preferably in the lower part of the assembly.

c) Requirements for cooling of converters used for propulsion are given in Sec.12.

1.2.7 Output voltage and frequency

The output voltage and frequency of the power supply units shall comply with the requirements for power supply systems given in Sec.2/ 1.

1.2.8 Short circuit current capabilities

Converters serving as power supplies shall be able to supply a short circuit current sufficient for selective tripping of downstream protective devices without suffering internal damage. Such selective tripping may be achieved by the utilisation of an automatic bypass. Current limiting power supplies, or power supplies limited by internal temperature may be used for single consumers.

1.2.9 By-pass arrangement

For converters serving as power supply units used as emergency or transitional source of power, or as power supply to essential or important consumers, a manual electrically independent bypass arrangement shall be provided unless redundant supply to the consumers is otherwise ensured.

1.2.10 Location of batteries

Requirements for location of batteries are given in Sec.2/ 9.4.

1.2.11 Protection and monitoring

a) Alarm shall be given for power supply failure and trip of unit

b) For IT distribution, alarm shall be given for secondary side earth fault (except in dedicated supply system for single consumers).

c) For liquid cooled converters where the cooling liquid is in direct contact with live parts, the conductivity shall be monitored, and high conductivity shall give alarm.

d) When harmonic filters are integrated in a converter, protection and monitoring as required in Sec.2/ 7.7.1 is required.

e) Additional requirements for monitoring of converters used in electrical propulsion systems are given in Sec.12.

f) For power supply units with batteries included, the following additional alarms shall be provided:

- when the charging of a battery fails, alternatively if the battery is being discharged
- when the automatic bypass is in operation for on-line units.
- operation of battery protective device.

g) Alarms shall be given to a manned control station.

h) Requirements for protection of batteries and distribution circuits are given in Sec.2/ 7.

1.2.12 Emergency stop, shutdown

a) In drives used for applications where emergency stop is required, the emergency stop circuit shall comply with Sec.2/ 8.5.1, i.e. the emergency stop signal shall be directly connected to trip the main power supply to the drive unit, either directly or through the control power circuit for the circuit breaker. Alternative arrangements independent of the software based control system may be accepted (e.g. pulse blocking, disconnection of control voltage to pulse amplifiers.)

b) Requirements for limited shutdown functions for steering and propulsion are given in Chapter Sec.12.

1.2.13 Restart

It shall be possible to restart the converter in a normal manner after a blackout. Local resetting /restarting of the unit shall not be necessary.

2 Inspection and Testing

2.1 General

2.1.1 Factory testing

a) Converters shall be tested at the manufacturer’s works. Type tests (TT) shall be carried out on a prototype of a converter or the first of a batch of identical converters. Routine tests (RT) shall be carried out on each converter.

b) The tests shall be documented. The documentation shall give information on make, type, serial no., all technical data necessary for the application of the converter, as well as the results of the required tests.

c) The result of type tests, and the serial number of the type tested converter, shall be specified in the documentation of test results for routine tests.

d) The type tests and routine tests that semi-conductor converters shall undergo are listed in Table 4.1.

Table 2.1: Testing and inspection of semi-conductor converters for power supply / UPS

No.	Task	Required test converter for power supply/ UPS	IEC test reference	ACS Rule requirement reference
1	Visual inspection[1)]	TT, RT		Sec.3/4/7
2	Function test (UPS switch test)[2)]	TT, RT	62040-3 pt. 6.2.3	Sec.7/1.1.3
3	Input voltage and frequency tolerance test	TT	62040-3 pt. 6.3.2	Sec.2/ 1.2
4	Stored energy and restored energy tests	TT	62040-3 pt. 6.3.9	Sec.2/ 4.1.2 c)
5	Insulation tests (High voltage test)	TT, RT	61800-5-1 pt. 5.2.3.2 60146-1-1 pt 7.2	Sec.7/ 2.1.2
6	Insulation resistance test [3)]	TT, RT	60146-1-1 pt 7.2.3.1	Sec.10/ 4.3.3
7	Rated current test/Full load test [4)]	TT	62040-3 pt 6.7.5	Sec.7/ 1.2
8	Temperature rise test	TT	60146-1-1 pt 7.4.2	Sec.3/ 2.3
9	Control and monitoring system (ref. also function test)	TT, RT	62040-3 pt. 6.2.4	Sec.7/ 1.2.11 and Ch.3
10	Short circuit test	TT	62040-3 pt 6.6.19	Sec.7/ 1.2.8
11	Cooling failure tests	TT, RT	61800-5-1 pt.5.2.4.5	Sec.7/ 1.2.6 & 1.2.11
12	Capacitor discharge	TT		Sec.7/ 1.2.3
13	Pressure test of coolant piping/hoses.	RT		Ch.1 Sec.11

1) Verification of separation, labeling, IP-rating, creepage and clearance distances.

2) Including check of auxiliary devices, properties of control equipment and protective devices.(IEC 60146-1-1 pt 7.5.1-3) In accordance with functional description and test program. The light load and function test may be performed with power modules identically to the ones that shall be installed onboard. The correct power modules may be tested separately.

3) Insulation resistance test shall be done in accordance with Sec.10 Table 4.1.

4) Full load current and over current test according to rating as required in 2.1.1 a) and 3.1.1 a).

2.1.2 High-voltage testing

High-voltage testing shall be carried out with test voltages as given in relevant product standard. These voltages given in IEC 60146-1-1 are reproduced in Table 4.2.

The test voltage shall be applied for 1 minute at 50/ 60 Hz for Type Tests, and minimum 1 s for Routine Tests.

If the circuit contains capacitors the test may be performed with a DC voltage.

2.1.3 Onboard testing

Semi-conductor converters for power supply and semi-conductor converters for motor drives shall be tested according to Sec.10/ 4, after installation onboard.

Table 2.2: Testing and inspection of semi-conductor converters for motor drives

No.	Task	Required test converter for power supply/ UPS	IEC test reference	ACS Rule requirement reference
1	Visual inspection 1)	TT, RT	61800-5-1 pt. 5.2.1	sec.3/4/7
2	Input voltage and frequency tolerance test	TT	62040-3 pt. 6.3.2	Sec.2/ 1.2
3	Light load and function test 2)	TT,RT	60146-1-1 pt 7.3.1 and 7.5	Sec.7/ 1.1.3
4	Impulse voltage test 3)	TT	61800-5-1 pt. 5.2.3.1	
5	Insulation tests (High voltage test)	TT, RT	61800-5-1 pt. 5.2.3.2 60146-1-1 pt 7.2	Sec.7/ 2.1.2
6	Insulation resistance test 4)	TT, RT	60146-1-1 pt 7.2.3.1	Sec.10/ 4.3.3
7	Rated current test/Full load test 5)	TT	60146-1-1 pt 7.3.2	Sec.7/ 1.2
8	Temperature rise test	TT	61800-5-1 pt. 5.2.3.9 60146-1-1 pt 7.4.2	Sec.3/ 2.3
9	Control and monitoring system (ref also function test)	TT, RT		Sec.7/ 1.2.11 and Ch.3
10	Cooling failure tests	TT, RT	61800-5-1 pt.5.2.4.5	Sec.7/ 1.2.6 & 1.2.11
11	Capacitor discharge	TT	61800-5-1 pt.5.2.3.7	Sec.7/ 1.2.3
12	Pressure test of coolant piping/hoses	RT		Ch1. Sec. 11
13	Breakdown of components test 6)	TT	61800-5-1 pt. 5.2.3.6.4	Sec.2/ 1.1.1 a), Sec.4/ 1.1.2 b)

1) Verification of separation, labeling, IP-rating, creepage and clearance distances.

2) Including check of auxiliary devices, properties of control equipment and protective devices.(IEC 60146-1-1 pt 7.5.1-3) In accordance with functional description and test program. The light load and function test may be performed with power modules identically to the ones that shall be installed onboard. The correct power modules may be tested separately.

3) To be performed if clearance and /or creepage distances are less than specified in Table 1.1, 1.2 and 1.3

4) Insulation resistance test shall be done in accordance with Sec.10 Table 4.1.

5) Full load current and over current test according to rating as required in 2.1.1 a) and 3.1.1 a).

6) Only applicable for variable speed drives larger than 1 MW.

Table 2.3: High voltage test

Nominal voltage of the system	Test voltages		
	Power frequency withstand voltage		Impulse voltage level
	AC r.m.s (V)	DC (V)	U_{imp} (kV)
<50	1250	1770	0.8
100	1300	1840	1.5
150	1350	1910	2.5
300	1500	2120	4
600	1800	2550	6
1000	2200	3110	8
>1000	3000	4250	8
3600	10000	14150	20
7200	20000	28300	40
12000	28000	39600	60
17500	38000	53700	75

Interpolation is permitted

Section 8 Miscellaneous Equipment

1 General

1.1 Socket outlets and plugs

1.1.1 General

a) Socket outlets and plugs with a rated current not exceeding 63 A in AC installations and 16 A in DC installations, shall be constructed for making and breaking the rated current by insertion and withdrawal of the plug, unless they are provided with an interlock as described in b).

b) Socket outlets with a rated current above 63 A AC or 16 A DC shall be provided with interlocks so that the plug can only be inserted and withdrawn when the switch is in the “off” position.

c) Socket outlets for portable appliances, which are not hand-held during operation (e.g. welding transformers, refrigerated containers), shall be interlocked with a switch regardless of rating, maximum 1 000 V can be accepted. At each such socket outlet, a warning sign shall be fitted, with text:

DANGER (maximum voltage) V AC ONLY FOR CONNECTION OF.... (type of equipment)....

d) Higher voltage socket outlets can only be used for special applications.

e) All socket outlets shall be provided with an earthing contact, except that this may be omitted in the

following cases:

- socket outlets on systems with voltage below 50 V AC or DC
- socket outlets with double insulated transformers for handheld equipment
- for distribution systems with insulated neutral; socket outlets in dry accommodation spaces where floor covering, bulkhead and ceiling linings are of insulating material. The resistance of the insulating material shall be at least 50 kOhm. Earth potential shall not be brought into the space, for instance through earth conductors, piping etc.

f) Precautions shall be taken so that a plug for one voltage cannot be inserted in a socket outlet for a different voltage. Alternatively, warning signboards shall be fitted.

1.2 Lighting equipment

1.2.1 General

a) The temperature rise of parts of luminaries that are in contact with the support shall generally not exceed 50°C.

b) The temperature rise limit is 40°C for parts installed in contact with flammable materials, such as for example wood.

c) For temperature rise of terminals, see Sec.3.

d) For other parts, temperatures according to recognised national or international standards, which take due consideration of the ambient temperatures on vessels, will be accepted.

e) Normally, gas discharge lighting equipment shall not be used.

1.2.2 Starting devices

Starting devices which develop higher voltages than the supply voltage are generally to be placed within the luminaries.

1.2.3 Discharge of capacitors

1.2.4 Each capacitor of 0.5 μF or more shall be provided with an arrangement that reduces the voltage to not more than 50 V within 1 minute after disconnection from the supply.

1.3 Heating equipment

1.3.1 General

Each separate heating element rated more than 16A is considered as a separate consumer, for which a separate circuit from a switchboard is required.

1.3.2 Temperature rises for heaters

The temperature rises in Table 1.2 are accepted.

Table 1.2: Temperature rises for heaters

Part	Temperature °C
Enclosure parts against the bulkhead	60
Other accessible parts	130 [1)]
Surface of heating elements inside enclosures with through air convection	280

1) Heating elements having a temperature rise exceeding 130°C are generally to be considered as “live parts” and shall be provided with suitable enclosures.

It is recommended to provide each heater with an interlocked over temperature thermostat with manual reset, accessible only by use of a tool. National regulations of the flag state might require such an over temperature cut out.

1.3.3 Space heaters

a) Space heaters are generally to be of the convection type, and suitable for installation on bulkheads.

Radiation heaters and other space heater types may be accepted after consideration in each case.

b) Space heaters are generally to be constructed with the top plate inclined about 30o, tight against the bulkhead in order to prevent clothing or other flammable material from covering the heaters.

c) Space heaters are normally to be installed on a free bulkhead space, with about 1 m free air above, and so that for example doors cannot touch the heaters. If not constructed as specified in b), an inclined perforated plate of incombustible material shall be mounted above each heater. Space heaters shall not be built into casings of woodwork or other combustible material.

1.3.4 Heating batteries for ventilation systems

Heating batteries in centralised ventilation systems shall be equipped with the following safety / control functions:

- heating elements shall be interlocked with respect to the air flow either directly controlled by the power to the fan or by measuring the airflow locally at the heating element
- heating elements shall be equipped with over temperature switch that can be reset manually only
- heating elements shall be equipped with thermostat control gear.

1.3.5 Space heaters combined with air-condition cabinets

The following additional requirements apply for space heaters integrated in air-conditioning cabinets:

- the maximum temperature rises specified in 1.3.2 shall be complied with, even when the air supply is completely shut off
- each cabinet shall be provided with an interlocked over temperature thermostat with manual reset, accessible only by use of tool
- combined cabinets for ceiling installation are accepted, the ceiling shall be constructed of incombustible materials.

1.3.6 Water heaters

a) Water heaters are normally to have insulated heating elements and shall be installed as separate units.

b) The requirements for temperature rises specified in Table 1.3 apply.

c) Each water heater shall be provided with a thermostat, sensing the water temperature and maintaining this at the correct level.

Electrode heaters and electrically heated steam boilers may be accepted after assessment of the arrangement in each case.

Heating by electric elements in the ship's water tanks may be accepted after design assessment of the arrangement in each case.

For pressure vessels, the requirements in Ch.1, Sec5 apply.

1.3.7 Oil heaters

a) Electric oil heaters are normally to be installed as separate units. Heating by electric heating elements in the ship's oil tanks is generally not allowed, but may be accepted after special design assessment of the arrangement in each case.

b) The requirements for temperature rises specified in Table 1.3 apply. In addition, the surface temperature of the heating elements shall be below the boiling point of the oil, under normal working conditions. Further limitation of the heating elements' temperature may be required.

c) Each oil heater shall be provided with a working thermostat, sensing the oil temperature and maintaining this at correct level under normal working conditions. In addition, each oil heater shall be provided with an interlocked over-temperature thermostat with manual reset, and with the sensing device installed in close proximity to the heating elements, so arranged that it will trip the elements, should they tend to overheat, or become dry. Other arrangements, ensuring equivalent protection, may be accepted after design assessment in each case.

Lubricating oil may deteriorate even at much lower element temperatures. The oil manufacturer should be consulted regarding the maximum acceptable element temperature.

1.4 Cooking and other galley equipment

1.4.1 General

a) Cooking equipment is generally to have insulated heating elements. Special equipment, such as for example high frequency ovens or electrode pots, shall be suitable for marine use, and installed in accordance with the manufacturer's instructions.

b) Electrode pots giving earth -connection of the system shall be fed from separate isolating transformers.

c) For oil pots, the requirements for oil heaters in 1.3.7 apply

d) The temperature rises in Table 1.3 are accepted.

Table 1.3: Temperature rises for cooking and other galley equipment

Part	Temperature °C
Enclosure parts against the bulkhead and decks	50
Other accessible surface parts, except hot plates with adjacent top plates	50
Hot plates with adjacent top plates, and heating elements	No limit 1)

1) Construction and temperatures shall be such that damage and hazards are avoided, when the equipment is used as intended.

Section 9 Cables

1 Application

1.1 General

1.1.1 General

a) This section of the rules contains requirements for selection, construction and rating of fixed electrical cables for permanent installation. Other applicable requirements in other sections shall also be complied with.

b) Requirements for cables for special applications are found in other parts of the rules. For cable selection see Sec.2 and for cable installation see Sec.10.

c) All electrical cables and wiring external to equipment shall be at least of a flame-retardant type. (This requirement is intended to cover SOLAS Ch. II-1/45.5.2)

1.1.2 Duty

a) Unless otherwise clearly stated, the rating of electrical cables for power supply to equipment shall be for continuous full load duty. Maximum environmental temperatures shall be as given in Sec.3 Table 2.1.

b) Requirements for cable sizing, and the tables for the current rating of different cable sizes, can be found in Sec.2.

1.1.3 Compliance with IEC

The design of all electrical cables installed shall comply with the requirements of applicable IEC Publications.

Permanently installed cables for power, control and instrumentation shall normally comply with the specifications of International Electrotechnical Commission's (IEC):

1) Publication No. 60092-350 Third Edition 2008-02 "Electrical installations in ships - Part 350: General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications"

2) Publication No. 60092-353 Second edition 1995-01. "Electrical installations in ships, Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltage 1 kV and 3 kV" for lighting and power cables.

3) Publication No. 60092-354 Second edition 2003-06. "Electrical installations in ships, Part 354: Single and threecore power cables with extruded solid insulation for rated voltages 6 kV (Um = 7.2 kV) up to 30 kV (Um = 36 kV)" for High Voltage cables.

4) Publication No. 60092-376 Second edition 2003-05. "Electrical installations in ships, Part 376: Cables for control and instrumentation circuit 150/250 V (300 V)".

2 General Cable Construction

2.1 Conductors

2.1.1 Conductors

All conductors shall consist of plain or metal-coated annealed copper according to IEC 60092-350 and shall be stranded according to IEC 60228 class 2 or class 5.

The use of other conductor metals may be considered in applications where copper cannot be used for chemical reasons. See also Sec.10/ 2.4.1.

2.1.2 Conductor cross section

a) Conductor cross sections shall be based on the rating of the over current and short circuit protection used.

However the minimum cross section shall be:

- 0.5 mm^2 for 250 V control and instrumentation cables and control and instrumentation switchboard wires
- 1.0 mm^2 for power circuit switchboard wires
- 1.0 mm^2 for 250 V and 0.6/1 kV power cables with the following exceptions: 0.75 mm^2 may be used for flexible cables supplying portable consumers in accommodation spaces, and also for internal wiring of lighting fittings, provided that the full load current is a maximum of 6 A and that the circuit's short circuit protection is rated at a maximum of 10 A
- 10 mm^2 for voltages above 1 kV.

b) Minimum cross sections of earth conductors are given in Sec.2. Earth conductors in cables shall be insulated, except for earth conductors as specified in Sec.2 Table 10.2.

2.1.3 Core marking

Cores for control and instrumentation cables shall be marked in accordance with relevant IEC standard.

2.2 Insulating materials

2.2.1 General requirements for insulating materials

a) The temperature classes and materials given in Table 2.1 may be used.

b) Electrical and mechanical characteristics shall comply with the specifications of table 2, 3 and 4, respectively of IEC 60092-351.

Table 2.1: Temperature classes for insulating materials

Material	Temperature °C
Polyvinyl chloride or (PVC)	70
Ethylene propylene rubber (EPR)	90
Halogen free ethylene propylene rubber (HF EPR)	90
Hard grade ethylene propylene rubber (HEPR)	90
Halogen free hard grade ethylene propylene rubber (HF HEPR)	90
Cross linked polyethylene (XLPE)	90
Halogen free cross linked polyethylene (HF XLPE)	90
Halogen free cross linked polyolefin (HF 85)	90
Silicone rubber, (S 95)1)	95
Halogen free silicone rubber (HF S 95) [1)]	95

1) Silicon rubber only to be used together with a varnished glass braid

2.3 Wire braid and armour

2.3.1 General

a) Cables designated as copper, copper alloy, aluminium alloy or galvanized steel wire braided shall comply with clause 3.8 of IEC 60092-353.

b) Braid and/or armour shall be separated from the core insulation by an inner non-metallic sheath, by tape or fibrous braid or roving.

c) Irrespective of the metal used, the nominal diameter of the braid wire shall be in accordance with Table 2.2.

Table 2.2: Nominal diameter of braided wire

Diameter of core assembly under braid [1)] (mm)	Minimum diameter of threadsin braid [2)] (mm)
$D \leq 10$	0.2
$10 < D < 30$	0.3
$D \geq 30$	0.4

1) Diameter under braid is fictitious and calculated by the method of IEC 60092-350 Appendix A.

2) The “coverage density” of the braid shall be in accordance with sub-clause 7.2 of IEC 60092-350 (2001-06).

2.4 Protective sheaths

2.4.1 General

a) Mechanical and particular characteristics of sheath materials shall comply with the specifications of table II and III respectively of IEC 60092-359.

b) Thickness of sheaths shall comply with sub-clause 3.7.3 of IEC 60092-353.

c) Sheath materials shall be such that the cables are at least flame retardant according to IEC 60332-1. (For cable bunches, see Sec.10/ 3.4.4.)

2.4.2 Temperature classes for protective sheaths

The temperature classes and materials shall be used in accordance with Table 2.3.

Table 2.3: Temperature classes for protective sheaths

Material	Temperature °C
Thermoplastic based on polyvinylchloride or copolymer of vinyl chloride and vinyl acetate, type ST1	60
Thermoplastic: — based on polyvinylchloride or copolymer of vinyl chloride and vinyl acetate, type ST 2 — Halogen free, type SHF1	85
Elastomeric or Thermosetting: — based on polychloroprene rubber, type SE 1 — based on chlorosulphonated polyethylene or chlorinated polyethylene rubber, type SH — Halogen free, type SHF2	85

3 High Voltage Cables

3.1 Construction of cables rated 1.8/3 kV

3.1.1 General

The construction of cables for permanent installations shall normally comply with the requirements of IEC 60092-353 second edition 1995-01. “Electrical installations in ships, Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltage 1 kV and 3 kV”.

3.1.2 Minimum thickness of insulating walls

The minimum average thickness of insulating walls shall be used in accordance with Table 3.1

Table 3.1: Minimum average thickness of insulating walls for power cables with rated voltage 1.8/3kV

Nominal cross section of conductor (mm^2)	Designation of the insulating compound	
	EPR HF EPR (mm)	XLPE HF XLPE HEPR HF HEPR (mm)
10 - 70	2.2	2.0
95 - 300	2.4	2.0
400	2.6	2.0
500	2.8	2.2
630	2.8	2.4

Table 3.1 is according to IEC 60092-353 for 1.8/3 kV cables.

3.2 Construction of high voltage cables rated above 1.8/3 kV

3.2.1 General

The construction and testing of cables for permanent installations shall normally comply with the recommendations of IEC 60092-354 second edition 2003-06, “Electrical installations in ships, Part 354: Single- and three-core power cables with extruded solid insulation for rated voltages 6 kV (U_m = 7.2 kV) up to 30 kV (U_m = 36 kV)”.

Other constructions and materials may be accepted when specially designed for special purposes.

For example “fire resisting” cables for circuits with short time duty (such as fire pumps), since the need for fire resisting characteristics of such cables make it difficult to apply screening as specified above.

3.2.2 Minimum thickness of insulating walls

The minimum average thickness of insulating walls shall be used in accordance with Table 3.2.

Table 3.2: Minimum average thickness of insulating walls for high voltage cables

Nominal cross sectional area of conductor mm^2	Nominal thickness of insulation at rated voltage U_0/U (U_m)				
	3.6/6 (7.2) kV mm	6/10 (12) kV mm	8.7/15 17.5) kV mm	12/20 (24) kV mm	18/30 (36) kV mm
10	2.5	-	-	-	-
16	2.5	3.4	-	-	-
25	2.5	3.4	4.5	-	-
35	2.5	3.4	4.5	5.5	-
50 to 185	2.5	3.4	4.5	5.5	8.0
240	2.6	3.4	4.5	5.5	8.0
300	2.8	3.4	4.5	5.5	8.0
400	3.0	3.4	4.5	5.5	8.0
500 to 10000	3.2	3.4	4.5	5.5	8.0

4 Low Voltage Power Cables

4.1 Construction of cables rated 0.6/1 kV

4.1.1 General

The construction of cables for permanent installations shall normally comply with the requirements of IEC 60092-353 second edition 1995-01. “Electrical installations in ships, Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltage 1 kV and 3 kV”.

4.1.2 Minimum thickness of insulating walls

The minimum average thickness of insulating walls shall be used in accordance with Table 4.1.

4.2 Switchboard wires

4.2.1 General

a) The insulation on switchboard wires shall be at least flame retardant according to IEC 60332-1. Insulation material shall be one of the following: PVC, HEPR, HF HEPR, HF XLPE, XLPE or HF85.

b) The minimum thickness of insulation walls shall be in accordance with Table 4.1.

Table 4.1: Minimum average thickness of insulating walls for power cables with rated voltage 0.6/1.0 kV

Nominal cross section of conductor (mm^2)	Designation of the insulating compound		
	PVC/A (mm)	EPR HF EPR S 95 (mm)	XLPE HF XLPE HF 85 HEPR HF HEPR (mm)
1.5	0.8	1.0	0.7
2.5	0.8	1.0	0.7
4 to 16	1.0	1.0	0.7
25 to 35	1.2	1.2	0.9
50	1.4	1.4	1.0
70	1.4	1.4	1.1
95	1.6	1.6	1.1
120	1.6	1.6	1.2
150	1.8	1.8	1.4
185	2.0	2.0	1.6
240	2.2	2.2	1.7
300	2.4	2.4	1.8
400	2.6	2.6	2.0
500	2.8	2.8	2.2
630	2.8	2.8	2.4

- For smaller cross sections than 1.5 mm^2, the insulation thickness shall not be less than specified for 1.5 mm^2.
- Table 4.1 is according to IEC 60092-353 for 0.6/1.0 kV cables.

4.3 Lightweight electrical cables

4.3.1 General

Lightweight electrical cables to be approved in accordance with the ACS type approval programme

5 Control and Instrumentation Cables

5.1 Construction of control and instrumentation cables rated 150/250 V

5.1.1 General

The construction of cables for permanent installations shall normally comply with the requirements of IEC Publication No. 60092-376 Second edition 2003-05. “Electrical installations in ships, Part 376: Cables for control and instrumentation circuit 150/250 V (300 V)”.

5.1.2 Minimum thickness of insulating walls

The minimum average thickness of insulating walls shall be used in accordance with Table 5.1.

Table 5.1: Minimum average thickness of insulating walls for control and instrumentation cables

Nominal cross section of conductor (mm^2)	Designation of the insulating compound		
	PVC/A EPR HF EPR (mm)	XLPE HF XLPE HEPR HF EPR (mm)	HF 85 S 95 HF S 95 (mm)
	Rated voltage 0.15/0.25 kV		
0.50	0.6	0.4	0.6
0.75	0.6	0.5	0.6
1.0	0.6	0.5	0.6
1.5	0.7	0.6	0.7
2.5	0.7	0.6	0.7

Table 5.1 is according to IEC 60092-376 second edition 2003-06

6 Data Communication Cables

6.1 General

6.1.1 General

Data communication cables to be approved in accordance with the ACS type approval programme.

7 Fibre Optic Cables

7.1 General

7.1.1 Fibre optic cables to be approved in accordance with the ACS type approval programme.

8 Inspection and Testing

8.1 General

8.1.1 Factory testing

a) Cables shall be tested at the manufactures works with the test specified in this part of the rules. Tests noted as Routine Test (RT) shall be carried out on all cables.

Tests noted as Product Sample tests (PST) shall be performed as random test at suitable intervals in order to ensure that products from subsequent production confirm to result of type tests, ensuring “equal production”.

b) The following inspection and tests shall be carried out according to IEC 60092-350 (2008-02):

- checking of cable construction (4.1.2.2)
- measurement of electrical resistance of conductor (5.2.2)
- voltage test (5.2.3)
- insulation resistance test (5.2.4)
- mechanical/particular characteristics of insulating compounds (8.3)
- mechanical/particular characteristics of sheathing compounds (8.4)
- hot set test for EPR and XLPE insulation and for SE1 and SHF 2 sheath (6.8).

Section 10 Installation

1 General Requirements

1.1 General

1.1.1 General

Reference is made to other sections of this chapter, especially Sec.2 for requirements affecting location, arrangements, and installation of systems in an early project stage, and Sec.3 to Sec.9 for requirements affecting the various equipment.

1.1.2 Equipment in hazardous areas shall be selected, located and installed according to Sec.11.

2 Equipment

2.1 Equipment location and arrangement

2.1.1 General

a) All electrical equipment shall be permanently installed and "electrically safe". This shall prevent injury to personnel, when the equipment is handled or touched in the normal manner. (Interpretation of SOLAS Ch. II-1/45.1.3)

b) All electrical equipment shall be selected and installed so as to avoid EMC problems. Thus preventing disturbing emissions from equipment, or preventing equipment from becoming disturbed and affecting its intended function(s).

c) Electrical equipment shall be placed in accessible locations so that those parts, which require manual operation, are easily accessible.

d) Heat dissipating electrical equipment as for example lighting fittings and heating elements, shall be located and installed so that high temperature equipment parts do not damage associated cables and wiring, or affect surrounding material or equipment, and thus become a fire hazard. (Interpretation of SOLAS Ch. II-1/45.7)

e) Equipment shall be installed in such a manner that the circulation of air to and from the associated equipment or enclosures is not obstructed. The temperature of the cooling inlet air shall not exceed the ambient temperature for which the equipment is specified.

f) All equipment of smaller type (luminaries, socket outlets etc) shall be protected against mechanical damage either by safe location or by additional protection, if not of a rugged metallic construction.

g) Requirements for installation of switchboards given in Sec.2/ 9.2.1 shall also be applied to installation of transformers.

h) Requirements for rotating machinery arrangement are given in Sec.2/ 9.3.

i) See Sec.2/ 9, for additional requirements for vessel arrangement.

2.1.2 Ventilation of spaces with electrical equipment

The ventilation shall be so arranged that water or condensation from the ventilator outlets does not reach any unprotected electrical equipment. See also Sec.2/ 9.1.1.

2.1.3 High voltage switchgear and control gear assemblies

Access to high voltage switchgear rooms and transformer rooms shall only be possible to authorised and instructed personnel.

Equipment located in machinery spaces may be considered as being accessible only to instructed personnel. The same applies to equipment located in other compartments that are usually kept locked, under the responsibility of the ship's officers.

2.1.4 Passage in front or behind switchgear

The passageways in front of and behind main and emergency switchboards shall be covered by mats or gratings of oil resistant insulating material, when the deck is made of a conducting material.

Mats complying with IEC 61111 or equivalent standard will be accepted.

2.1.5 Transformers

Liquid immersed transformers shall be installed in an area or space with provisions for complete containment and drainage of liquid leakage.

2.1.6 Heating and cooking appliances

a) All combustible materials close to heating and cooking appliances shall be protected by incombustible or insulating materials.

b) Cabling and wiring (feeding) shall be suitable for the possible higher temperature in the termination room of such equipment.

c) Additional protection of IR–type of open heating elements shall be installed, if necessary to guard against fire and accidental touching.

2.2 Equipment enclosure, ingress protection

2.2.1 Enclosure types in relation to location

Equipment enclosures shall comply with Table 2.1 in relation to the location of where it is installed and for high voltage equipment, see Sec.3/ 4.

Table 2.1: Enclosure types in relation to location

Location		*Switchgear and transformers*	*Luminaries*	*Rotating machines*	*Heating appliances*	*Socket outlets*	*Miscellaneous such as switches and connection boxes*	*Instrumentation components*
Engine and boiler rooms 15)	Above the floor	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44	IP 44
	Below the floor	N	IP 44	IP 44	IP 44	N	IP 44	IP 56
	Dry control rooms and switchboard rooms 1)	IP 21	IP 22	IP 22	IP 22	IP 22	IP 20	IP 20
	Closed compartments for fuel oil and lubrication oil separators	IP 44	IP 44	IP 44	IP 44	N	IP 44	IP 44
Fuel oil tanks 2)		N	N	N	N	N	N	IP 68
Ballast and other water tanks, bilge wells 2)		N	N	IP 68	IP 68	N	N	IP 68
Ventilation ducts		N	N 13)	IP 44 13)	N	N	N	13)
Deckhouses, forecastle spaces, steering gear compartments and similar spaces		IP 22 3)	IP 22	IP 22 3)	IP 22	IP 44	IP 44	IP44
Ballast pump rooms, columns below main deck and pontoons and similar rooms below the load line		IP 44 14)	IP 44	IP 44 14)	IP 44	IP 56 5)	IP 56 5)	IP 56 5)
Cargo holds 4)		N	IP 55	IP 44	N	IP 56 5)	IP 56 5)	IP 56 5)
Open deck, keel ducts		IP 56	IP 55	IP 56 6)	IP 56	IP 56 5)	IP 56 5)	IP 56
Battery rooms, paint stores, welding gas bottle stores or areas that may be hazardous due to the cargo or processes onboard 7)		EX 12)	EX 12)	EX 12)	EX 12)	EX 12)	EX 12)	EX 12)
Dry accommodation spaces		IP 20	IP 20	IP 20	IP 20	IP 20	IP 20 8)	IP 20
Bath rooms and showers		N	IP 44 11)	N	IP 44	N 9)	IP 56 11)	IP 56 11)
Galleys, laundries and similar rooms 10)		IP 44	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44

(N: Normally, not accepted for installation in this location.)

1) Switchboards in dry control rooms and switchboard rooms with IP 21 shall have a roof with eaves. If there is a chance of dripping water from piping, condensed water, etc. then a higher IP rating may be necessary. If there is no chance of dripping water, and the room is equipped with air conditioning system, the IP rating for control desks may be as required for dry accommodation spaces.

2) For cable pipes and ducts through fuel oil and water tanks, see 3.7.

3) Such equipment shall be provided with heating elements for keeping it dry when not in use, regardless if IP rating. The heating elements shall normally be automatically switched on when the equipment is switched off. Continuously connected heating elements may be accepted provided the maximum allowed temperatures are maintained when the equipment is in operation.

4) For enclosures in cargo holds, placed so that they are liable to come into contact with the cargo or cargo handling gear, see Sec.3/ 4.1. For truck battery charging arrangements, see Sec.2/ 9. For special category spaces in passenger vessels and ferries see SOLAS Reg. II-2/37. For such cargoes, also national regulations apply. For vessels carrying cars with fuel in their tanks see SOLAS Reg. II-2/20 3.2.

5) IP 44 may be accepted, when placed in a box giving additional protection against ingress of water. Equipment for control and indication of watertight doors and hatches shall have watertightness based on the water pressure that may occur at the location of the component, if intrusion of water can affect the control or indication system. For passenger vessels, requirements to IP rating for watertight doors are given in SOLAS II-1 Regulation 15.

6) Motors on open deck shall have ingress protection IP 56, and either:

- be naturally cooled, i.e. without external cooling fan
- be vertically mounted and equipped with an additional steel hat preventing ingress of water or snow into any external ventilator
- or be equipped with a signboard requiring that the motor shall only be used in port, and be provided with additional covers (e.g. tarpaulins) at sea.

7) For arrangement and connection of batteries, see Sec.2. For installations in paint stores, welding gas bottle stores or areas that may be hazardous due to the cargo or processes onboard, the requirements in Sec.11 shall be complied with. Electrical equipment and wiring shall not be installed in hazardous areas unless essential for operational purposes.

8) Connection boxes may be accepted installed behind panels in dry accommodation spaces provided that they are accessible through a hinged panel or similar arrangement.

9) Socket outlets shall be so placed that they are not exposed to splash, e.g. from showers. Circuits for socket outlets in bathrooms shall either be fed from a double insulated transformer, or be equipped with earth fault protection with a maximum release current of 30 mA.

10) Stoves, ovens and similar equipment may be accepted with IP 22 when additionally protected against water splash by hose or washing of the floor.

11) Lower degree of protection may be accepted provided the equipment is not exposed to water splash.

12) Type of ingress protection shall be in accordance with the minimum requirements in Sec.11 or minimum requirements in this table, whichever is the strictest. Minimum explosion group and temperature class shall be one of those specified in Sec.11 (some national regulations may limit the choice of type of protection).

13) Luminaries and instrumentation components may be accepted after special consideration. It shall be observed that a ventilation duct may be a hazardous area, depending upon the area classification at the ends of the duct.

14) Electric motors, switchgear and starting transformers for thrusters shall be equipped with heating elements for standstill heating. Provided the space will not be used as pump room for ballast, fuel oil etc., the thrusters motor may be accepted with IP22 enclosure type.

15) Electrical and electronic equipment and components located in areas or in the vicinity of areas protected by Fixed Water-Based Local Application Fire-Fighting

Systems as required by SOLAS Ch. II-2/10 5.6 using fresh water shall be to a degree of protection not less than IP22.

When salt water is used, electrical and electronic equipment and components located in areas, or in the vicinity of areas, protected shall be to a degree of protection not less than IP44, unless the manufacturer of the electrical and electronic equipment or components submits evidence of suitability using a lower degree of protection (e.g. IP23, IP22, etc.) restricted to:

- For the natural air cooled static power equipment (e.g. starter, distribution panel, transformer, lighting etc.) at least IP23 is required.
- For the natural air cooled electronic equipment mounted or located on the protected system (e.g. sensors, actuators, etc.), at least IP44 is required.
- For the rotating machinery and mechanically air cooled type equipment (e.g., rotating machinery, air cooled SCR panel, etc.) which needs the forced cooling air from outside the equipment, the lower degree than IP44 may be accepted if measures are taken, in addition to ingress, to prevent the ingest of water. The terminal boxes shall be of at least IP44.

Generators with a lower degree of protection as IP44 may be used if they are separated to each other in a way that the water used for the FWBLAFFS (e.g. water mist, water drops) will harm only the set concerned.

2.3 Batteries

2.3.1 General

Battery installations shall comply with the requirements in Sec.2/ 9, regarding requirements for their location, compartments etc.

2.3.2 Materials

The following requirements apply to all stationary accumulator batteries:

a) Battery stands, boxes and lockers shall be fixed to the vessel's structure. The batteries shall be fixed or supported on the shelves. Shelves and fixings shall be constructed to withstand the forces imparted from the batteries, during heavy sea.

b) All materials used for the construction, including ventilation ducts and fans, shall be corrosion resistant or shall be protected against corrosion by suitable painting, with consideration given to the type of electrolyte actually used.

c) The materials shall be at least flame retardant, except that impregnated wood can be used for the support of battery cells, and for battery boxes on deck.

d) Except when corrosion resistant materials are used, the shelves in battery rooms and lockers and the bottom of battery boxes shall be covered with a lining of corrosion resistant material, having a minimum thickness of 1.5 mm and being carried up not less than 75 mm on all sides (e.g. lead sheath for lead and acid batteries, steel for alkaline batteries). If the shelves in battery rooms and lockers are of corrosion resistant materials and the floor is not, either the shelves or the floor shall be covered with such lining.

2.3.3 Testing

The following tests and inspections shall be performed before batteries are put into service:

- ventilation shall be verified, including natural ventilation
- capacity tests, voltage measurements
- alarms and monitoring functions.

2.3.4 Marking and signboards

See 2.5.2 for the requirements for marking and signboards, with respect to battery installations.

2.4 Protective earthing and bonding of equipment

2.4.1 General

a) Earth conductors shall normally be of copper. However, other suitable materials may be accepted if, for example the atmosphere is corrosive to copper.

b) The earth conductor's cross section shall be equivalent to that of copper with regard to conductivity.

Applicable arrangements and cross sections are given in Sec.2 Table 10.2.

c) The connection to the hull of earth conductors or equipment enclosure parts, which shall be earthed, shall be made by corrosion resistant screws or clamps, with cross section corresponding to the required cross section of earth given in Sec.2/ 10.4.1.

d) Earthing screws and clamps shall not be used for other purposes. Suitable star washers and conductor terminals shall be used, so that a reliable contact is ensured.

e) Metal enclosures or other exposed conductive parts being a part of electrical equipment shall be earthed by fixing the metal enclosure or exposed parts in firm (conductive) contact to the hull (main earth potential) or by a separate earth conductor.

f) Portable equipment shall always be earthed by an earth conductor contained in the flexible supply cable.

g) All extraneous conductive parts supporting electrical equipment and cable support systems, that is ladders, pipes and ducts for electrical cables, are considered to be in firm electrical contact with the hull as long as elements are welded or mechanically attached (metal to metal without paint or coating) with a star washer, thereby ensuring a firm conductive contact. If firm electrical contact is not achieved, the parts shall be bonded by a separate copper conductor between extraneous parts and the hull.

h) Additional precautions shall be applied regarding earthing of portable electrical equipment for use in confined or exceptionally damp spaces where particular risks due to exposure and conductivity may exist.

i) High voltage metal enclosures and the steel hull shall be connected by a separate earth conductor. The enclosures fixing device shall not be the sole earthing connection of the enclosure.

j) If a separate earthing conductor is chosen for equipment, then the connection of the separate earth conductor to the hull, (safe earth potential) shall be made in an accessible position. The conductor shall be terminated by a pressure type cable lug onto a corrosion protected bolt, which shall be secured against loosening. Other suitable terminating systems for direct receipt of the conductor may be considered.

Additional precautions in i) might be: The equipment having extra safe low voltage, or for ordinary 230 V equipment, by using a safety transformer system or by having an earth fault switch of maximum 30 mA in front of the circuit.

2.4.2 Exceptions to the earthing or bonding requirements

a) If one of the following conditions is fulfilled, the requirements in 2.4.1 may be omitted:

- equipment supplied at a voltage not exceeding 50 V DC or AC between conductors. Auto-transformers shall not be used for the purpose of achieving this voltage
- equipment supplied at a voltage not exceeding 250 V by safety isolating transformer and the transformer is supplying only one consumer device
- equipment constructed in accordance with the principle of double insulation.

b) Parts fixed to non-conductive materials, and separated from current carrying parts and from earthed parts in such a way that they cannot become live under normal or electrical fault conditions.

c) Bearing housings which are insulated in order to prevent circulating currents.

d) Cable clips do not need protective earthing.

2.4.3 Dimension of protective earth and bonding conductors

For dimension of protective earth and bonding conductors, see Sec.2.

2.5 Equipment termination, disconnection, marking

2.5.1 General

All equipment shall be installed and terminated in accordance with manufacturer's instructions to ensure that correct functions and safe properties are contained.

2.5.2 Signboards for equipment

a) Labels (nameplates) of durable material, bearing clear and indelible indications, shall be so placed that all equipment necessary for the operation can be easily identified. All labels shall be permanently fixed.

b) All equipment shall, if necessary, be marked so as to ensure correct use. Signboards giving guidance for safe use, or conditions for use, shall be fitted, if necessary, in order to avoid inadvertent or dangerous operation of equipment and or systems.

c) “High voltage” warning signboards are required on all high voltage equipment.

d) High voltage cables shall be suitably marked with “high voltage” warning signboards, at least for every 20 m, so that a signboard is always visible, unless colour coding of cables has been used.

e) On rotating machines, on deck, that are not naturally cooled, i.e. with external cooling fan, a signboard shall be fitted on the machines requiring that the machines shall only be used in port and be provided with additional covers (e.g. tarpaulins) when at sea. See Table 2.1, note 6.

f) At each socket outlet for portable appliances where 1 000 V is accepted, (e.g. welding transformers, refrigerated containers etc., which are not hand-held during operation) an additional warning sign shall be fitted, with the text:

DANGER (maximum voltage) V AC ONLY FOR CONNECTION OF....(type of equipment)....

g) Signboards shall be fitted in battery rooms and on doors or covers of boxes or lockers, warning against risk for explosive gas, smoking and the use of naked lights.

h) All batteries shall be provided with labels (nameplates) of durable material, giving information on the application for which the battery is intended, make, type, voltage and capacity. Instructions shall be fitted either at the battery or at the charging device, giving information on maintenance and charging.

i) Battery systems above 50 V shall be marked with special visible warning signboard, i.e. “Warning xxx voltage”.

j) Emergency lighting fixtures shall be marked for easy identification.

2.6 Neon lighting

2.6.1 General

a) Neon tubes for voltage above 1 000 V, 50 Hz, shall be installed at least 2.5 m above the floor.

b) Each circuit shall have circuit protection rated at maximum 16 A.

c) The on and off switch shall be clearly marked. The switch is not accepted on the secondary side of the transformer.

d) Cables and wires shall have braiding, armour or be fitted in an earthed pipe.

3 Cables

3.1 General

3.1.1 General

a) Cable sizing with respect to current carrying capacity and short circuit withstand capabilities shall comply with the requirements in Sec.2.

b) For requirements for cable construction and materials, see Sec.9.

Use of cables with low emission of smoke in case of a fire, should be considered for all indoor installations. In areas where equipment sensitive to corrosion is installed or kept, use of Halogen free cables should be considered to avoid corrosive smoke in case of a fire, as far as is practicable.

3.1.2 Painting of cables

Electrical cables may be coated or painted, but this shall not adversely affect the mechanical, chemical or fire resistant characteristics of the sheath.

The Society has experience from cables damaged by two component epoxy painting bonding to the sheath material.

Unless the yard has experience with the combination of paint and cable type used, the manufacturers should be consulted by the yard.

3.1.3 Cable braid/armour

Cables with braid or armour without outer sheath for corrosion protection is accepted with the following exceptions:

- when installed in hazardous areas (see Sec.11/ 4.2.1)
- when the braiding is used for protective earthing.

3.1.4 Corrosion protection

Braid or armour of lead, bronze or copper shall not be installed in contact with aluminium alloy structures, except in dry accommodation spaces.

3.1.5 Flexible cables

The use of flexible cables shall be limited to applications where flexibility is necessary, and the lengths of such flexible cables shall be kept as short as practicable. Special requirements may be made to the type, installation and protection of flexible cables, depending upon the application.

3.1.6 High voltage cables

Installation of high voltage cables in accommodation spaces is not permitted unless required by the application.

The necessity for special protection shall be evaluated when high voltage cables are installed in accommodation spaces, for prevention of harmful effects to personnel from cable short circuits, and strong electromagnetic fields.

3.1.7 Fibre optic cables

Tensile stress applied to fibre optic cables for any reason during the installation period or during normal operation shall not exceed the maximum allowed value stated by the manufacturer.

3.2 Routing of cables

3.2.1 General

General requirements for routing of cables are given in Sec.2/ 9.5.

3.2.2 Segregation of low and high voltage cables

a) Low voltage power cables shall not be bunched together with, or run through the same pipes as, or be terminated in the same box as, cables for high voltage.

b) High voltage cables are not to be installed on the same cable tray for the cables operating at the nominal system voltage of 1 kV and less. (according to IACS UR E11)

3.2.3 Special precautions for single core cables

When the use of single core cables or parallel connection of conductors of multicore cables is necessary for AC circuits with nominal current exceeding 20 A the following apply:

a) Armour or braiding on single core cables shall be of non-magnetic type.

b) If provided, the non-magnetic armour or braiding shall be earthed at one end, only.

c) Single core cables belonging to the same circuit shall be contained within the same pipe, conduit or trunk. Clamps that fix them shall include all phases.

d) The phases shall be laid as close as possible and preferably in a triangular formation.

e) Magnetic material shall not be used between single core cables for one consumer. All phases belonging to the same circuit shall be run together in a common bulkhead penetration (MCT), unless the penetration system is of non-magnetic material. Unless installed in a triangular formation, the distance between the cables and magnetic material shall be 75 mm.

f) Circuits with several single core cables for each phase (forming groups) shall follow the same route and have the same cross sectional area.

g) The cables belonging to the same phase shall as far as practicable alternate with those of the other phases, so that an unequal division of current is avoided.

h) For fixing of single core cables, see 3.5.6.

i) For DC-installations with a high “ripple” content (e.g. thyristor (SCR) units), the requirements above are applicable.

3.2.4 Accessible cable runs

a) Cable runs shall be accessible for later inspection, except cables carried in pipes.

b) When cable runs are carried behind wall lining in accommodation spaces (except when carried in pipes), the panels shall be hinged or fixed for example by screws, so that they can be removed for inspection without damaging the cable or the bulkhead.

c) Exceptions can be made for cables to light fittings, switches, socket outlets etc. in dry accommodation spaces, when the deckhead and bulkhead constructions are made of incombustible materials.

3.3 Penetrations of bulkhead and decks

3.3.1 General

a) Penetrations shall meet the fire and watertight integrity of the bulkhead or deck. The penetrations shall be carried out either with a separate gland for each cable, or with boxes or pipes filled with a suitable flame retardant packing or moulded material. The installation shall be in accordance with the manufacturers' installation instructions.

b) Fire rated penetrations shall be documented as required by Ch.4 .

Penetrations of watertight bulkheads should be placed as high as practicable.

3.3.2 Thermal insulation

Cable runs shall not be laid in or covered with thermal insulation (e.g. through refrigerated cargo holds), but may cross through such insulation.

3.3.3 Hot oil pipes near to penetrations

3.3.4 The distance from cable penetrations to flanges of steam or hot oil pipes shall not be less than 300 mm for steam or hot oil pipes with diameter D $\leq$ 75 mm, and not less than 450 mm for larger pipes.

3.3.5 Chafing

Penetrations of bulkheads and decks shall be such that the cables are not chafed. (Interpretation of SOLAS Ch. II-1/45.5.5)

3.3.6 Mechanical support of penetrations

The cable shall have mechanical fixing on both sides of a bulkhead penetration.

3.4 Fire protection measures

3.4.1 General

The cable installation shall be protected against fire, fire spreading, thermal, mechanical, corrosive and strain damage. (Interpretation of SOLAS Ch. II-1/45.5.2)

3.4.2 Flammable materials

Cables shall not be installed in contact with flammable materials such as wooden bulkheads, when the conductor temperature exceeds 95°C at full load, at the actual ambient temperature.

3.4.3 Precautions against fire spreading in cable bunches

Cables that are installed in bunches shall have been tested in accordance with a recognized fire test for cables installed in bunches, such as the test specified in IEC 60332-3, or be provided with protection according to 3.4.4.

A cable bunch in this context is defined as five or more cables laid close together in trunks from machinery spaces and in spaces with a high risk of fire, and more than 10 cables in other areas.

3.4.4 Cable bunches not complying with IEC 60332-3 or other recognized standard fire spread test.

a) Cable bunches, not complying with flame retardant properties according to IEC 60332-3, shall be provided with fire stops having at least class B-0 penetration properties at the following locations:

- cable entries at the main and emergency switchboards
- where cables enter engine control rooms
- cable entries at centralized control panels for propulsion machinery and essential auxiliaries
- at each end of totally enclosed cable trunks.

Additional fire stops need not be fitted inside totally enclosed cable trunks.

b) In enclosed and semi-enclosed spaces, cable runs not complying with flame retardant properties according to IEC 60332-3, shall be provided with fire stops having at least B-0 penetrations:

- at every second deck or approximately 6 metres for vertical runs
- at every 14 metres for horizontal.

Alternatively, to additional fire stops, fire protective coating may be applied to the cable bunch according to the following:

- to the entire length of vertical runs
- to at least 1 m in every 14 m for horizontal runs.

Alternatively, type approved fire protective coating or mats installed as described in the type approval certificate can be accepted.

3.4.5 Fire resistance of penetrations

Where “A” or “B” class bulkheads or decks are penetrated for the passage of electrical cables, arrangements shall be made to ensure that the fire resistance of the bulkheads or decks, is not impaired.

Cable transits in “A”, “B” or “F” class divisions should not have more than 40% of the inside cross sectional area of the transit occupied by cables. The installation should be in accordance with the transit manufacturer's instructions.

3.4.6 Fire resistant cables

For requirements for fire resistant cable, see Sec.2/ 10.1.2.

3.5 Support and fixing of cables and cable runs

3.5.1 General

Cable ladders, trays and cable pipes shall not be used for carrying water, oil or steam pipes. Hydraulic pipes for valve control are exempted. Other exemptions may be considered in each case.

3.5.2 Cable ladder or tray material and mechanical requirements

a) Cable ladders and trays with their fixing devices shall be made of steel adequately protected against corrosion or type tested non-metallic materials with equal properties.

b) When fixed to aluminium structures, aluminium alloy cable ladders and trays may be used. Other materials may be accepted upon special consideration.

c) Cable trays or protective casings made of plastic materials shall be supplemented by metallic fixing and straps such that in event of a fire they, and the cable affixed, are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route.

The load on the cable trays or protective casings shall be within the Safe Working Load (SWL). The support spacing shall not be greater than manufacturer's recommendation nor in excess of spacing at the SWL test. In general the spacing shall not exceed 2 m. (IACS UR E 16).

The term “cable ladder” includes support brackets. The term “cable tray” means constructions being formed by continuous tray plates or structural steel.

Adequate protection against corrosion may be stainless steel, hot dipped galvanised steel or black steel adequately coated in accordance with a marine coating standard.

3.5.3 Mechanical protection of cables and cable runs

a) Cables shall be so installed that they are not likely to suffer mechanical damage. If necessary, they shall be protected by providing the cable runs with covers of plates, profiles or grids, or by carrying the cables in pipes.

b) Below the floor in engine and boiler rooms and similar spaces, cables that may be exposed to mechanical damage during maintenance work in the space, shall be protected in accordance with a).

c) All cables that may be exposed to mechanical damage, shall be protected by covers of steel plates, steel grids or profiles, or by being carried in steel pipes, e.g. on weather decks, in cargo hold areas, and through cargo holds.

As an alternative the covers can be made of perforated steel plates or grids with mesh opening maximum 25 mm, having at least the same impact strength as a 4 mm steel plate. Exemptions can be accepted when the location of the cable run is such that in all probability cargo or cargo handling gear cannot come into contact with the cable run. When cable runs are fixed to aluminium structures, aluminium may be used instead of steel.

3.5.4 Cable bends

a) The internal radius of low voltage cable bends, which are not subjected to movement by expansion, shall be in accordance with the manufacturers' recommendation, but normally, not less than given in Table 3.2.

b) The minimum internal bending radius for high voltage cables shall be in accordance with the manufacturers' recommendations.

Table 3.2: Cable 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	6 D
	Metal braid screened or armoured	Any	6 D
	Metal wire armoured Metal tape armoured or metal sheathed	Any	6 D
	Composite polyester or metal laminate tape screened units or collective tape screening	Any	8 D
Thermoplastic or thermosetting with sector shaped copper conductors	Any	Any	8 D

3.5.5 Fixing of cables

a) Cables shall be fixed by clips, saddles or bands, except when carried in pipes.

When cables are fixed on a tray by means of clips or straps of non metallic material and these cables are not laid on top of horizontal cable trays or supports, metallic cable clips or saddles shall be added at regular distances (e.g. 1 to 2 m) in order to retain the cable during a fire.

b) Flame retardant polymer material may be used for cable fixing if the material is resistant to heat and light radiation, affecting the material during the lifetime of the vessel.

c) The spacing between supports or fixing shall be suitably chosen according to the type of cable and the probability of vessel movement and vibration at the actual point of installation, as given in Table 3.3.

d) When cables are installed on top of horizontal ladders or trays, the fixing distance may be 3 times larger than given in Table 3.3. However, when cable runs are subjected to water splashing on weather decks the maximum distance between fixings of cable and its support (cable trays or pipes) shall be 500 mm.

e) When cable runs are installed directly on aluminium structures, fixing devices of aluminium shall be used.

For mineral insulated cables with copper sheath, fixing devices in metallic contact with the sheath shall be of copper alloy.

Table 3.3: Spacing of fixing points for cables

External diameter of cables		Non-armoured or unbraided cables (mm)	Armoured or braided cables (mm)
Exceeding (mm)	Not exceeding (mm)		
-	8	200	250
8	13	250	300
13	20	300	350
20	30	350	400
30	-	400	450

3.5.6 Fixing of single core cables

In order to guard against the effects of electro dynamic forces developing on the occurrence of a short circuit or earth fault, single core cables shall be firmly fixed, using supports of strength adequate to withstand the dynamic forces corresponding to the prospective fault current at that point of the installation. The fixing clamps of the cables should not damage the cable when the forces affect the cables during a 1 s short circuit period.

Manufacturer's instructions for installation with respect to prospective fault current should be followed.

3.6 Cable expansion

3.6.1 Expansion of cable runs

Cable runs and bulkhead penetrations shall be installed so that they do not take up hull forces caused by the vessel's movements, different load conditions and temperature variations.

3.6.2 Cables across expansion joints

a) The installation of electric cables across expansion joints in any structure shall be avoided. Where this is not practicable, a loop of electric cable of length sufficient to accommodate the expansion of the joint shall be provided. The internal radius of the loop shall be at least 12 times the external diameter of the cable.

b) All cables shall be fastened on each side of an expansion loop, such that all relative movement between structure and cable is taken up at this point, and not in the rest of the cable run.

3.6.3 Cable trays along main decks

a) Cable trays or pipes run in the length of the vessel shall be divided into a number of sections each rigidly fixed to the deck at one point only and sliding supports for the rest of the section.

b) The expansion and compression possibility shall ensure that the cables do not become fully stretched during operation. The expansion and compression possibility shall be at least ±10 mm for every 10 m section length from the fixing point.

c) The cables shall be fixed to the tray as required by 500, and at each expansion and compression point, the cable shall have adequate room for bending and stretching.

d) When pulled in pipes, the cable shall be fixed in order to avoid chafing. Each pipe section shall be installed without the possibility for expansion within the section.

When pipes are joined by the use of expansion joints, the pipe ends will not satisfy the above requirements.

3.7 Cable pipes

3.7.1 Cable pipes

a) Cables that are carried in the same pipe shall be of such construction that they cannot cause damage to each other.

b) The pipes shall be suitably smooth on the interior and protected against corrosion. The ends shall be shaped or bushed in such a way that the cable covering is not damaged. The pipes shall be fitted with drain holes.

c) When cable pipes are installed vertically due attention shall be paid to the cable's mechanical self carrying capacity. For longer pipes, suitable installation methods shall be used, e.g. sand filling.

d) Cable pipes shall not include expansion elements required by 3.6.

3.7.2 Cable pipe material

a) Cable pipes shall be made of steel or type tested non-metallic materials.

b) The cable pipe material shall not have less resistance against fire than required from the cable itself.

c) Aluminium cable pipes may be used if fixed to aluminium structures.

3.7.3 Corrosion protection of cable pipes

Steel cable pipes on deck, through cargo holds, in keel ducts, pump rooms and similar wet spaces, and in water and fuel oil tanks shall be internally and externally galvanised, or shall have an equivalent effective corrosion protection.

3.7.4 Condensation in cable pipes

Cable pipes with connection and draw boxes shall be arranged so that condensed water is drained out of the system.

3.7.5 Bending radius of pipes

The bending radius of cable pipes shall be sufficiently large so that “drawing-in” of the cables does not cause damage to the cables, and in no case less than:

- the minimum bending radius of the cables according to 3.5.4
- twice the internal diameter of the pipe.

3.7.6 Filling of cable pipes

The sum of the cables' total cross section, based on the cables' external diameter, shall not exceed 40% of the pipe's internal cross section. This does not apply to a single cable in a pipe.

3.7.7 Connection and draw boxes

a) Connection and draw boxes shall have at least the same wall thickness as required for the pipes, and shall be of steel, with exemption for aluminium alloy pipes, where galvanized cast iron or aluminium alloy shall be used.

b) All connection and draw boxes shall be accessible (for boxes behind panels in accommodation spaces, see Table 2.1, footnote 8).

3.8 Splicing of cables

3.8.1 Splicing

a) Splicing of cables by using a kit or system from a recognised manufacturer is accepted.

b) The two cables spliced shall have the same basic construction.

Splicing is meant as the direct continuation of cable lengths and not transfer into a distribution box.

The splicing kit should contain the following as minimum:

- connectors for conductors, of correct size
- replacement insulation

- replacement inner sheet or common covering
- connector for braiding or armour
- replacement outer sheath with minimum fire properties as the original sheath
- splicing instructions.

3.8.2 Splicing in junction boxes

a) Junction boxes may be used for splicing of cables when the following is complied with:

- the boxes shall be located in accessible places
- cables for main and emergency circuits shall not be spliced in the same box
- cables for different systems and/or voltages shall be clearly marked and separated.

b) Junction boxes used for splicing shall be marked with voltage level(s) and box identification.

c) All conductors shall be connected in permanently fixed terminals.

3.9 Termination of cables

3.9.1 Termination of data communication cables

Data cables shall be installed such that the insulation is fixed as part of the termination. For stranded conductors, all strands shall be fixe by the termination.

3.9.2 High voltage cables

High voltage cable shall have ending or termination kits approved or recommended from the cable manufacturer.

The termination kit shall be appropriate for the voltage level in question.

3.9.3 Cable entrance

Cable entrances in equipment shall at least have the same IP rating as the equipment itself in order to maintain the integrity of the enclosure.

All termination of conductors and braiding shall be made inside enclosures. Where space does not permit this arrangement, then cable braids/sheaths may be bonded to earth in a protected none corrosive area below the enclosure. Cable braids/sheaths although bonded to earth below the enclosure should still be left long enough to be stopped within the enclosure and thereby reduce EMC effect.

See Sec.11 for requirements for cable glands, with respect to equipment in hazardous areas.

3.9.4 Earthing of cable metal covering

a) All metal coverings (braiding or armour) of power cables shall be electrically connected to the metal hull (earth) of the vessel at both ends of the cable, except for short circuit proof installation where the braiding shall be insulated with crimp-on sleeve. Single point earthing is permitted for final sub circuits and in those installations (such as for control or instrumentation) where it is required for technical reasons. For earthing of cables in hazardous areas, see Sec.11/ 4.2. (Interpretation of SOLAS Reg. II-1/45.5.1)

b) The electrical continuity of all metal coverings shall be ensured throughout the length of the cables, at joints, tappings and branching of circuits.

c) When metal coverings (braiding or armour) are earthed at one end only, the floating end shall be properly insulated.

d) Special DC cables with a high ripple content (e.g. for thyristor equipment) and single core cables for AC shall be earthed at one end only.

e) The metal covering or braiding or armour of cables may be earthed by means of glands intended for that purpose. The glands shall be firmly attached to, and in effective metal contact with the earthed enclosure, of equipment.

f) The braiding or armour shall be connected directly from the cable to dedicated earth terminal or bar. Special clamp-on connections for making the connection from metal covering or armour or braiding, to the earth terminal might be accepted if being of a recognised type intended for the purpose. Earth connection of metal covering shall not be made by ordinary soldering or other untested solutions.

g) Screens around individual pairs for earthing for EMC purposes in cables for control, electronic, communication and instrumentation equipment, shall normally be earthed at one end only. Cables having both individual screen and common screen (or braiding) shall have these metal coverings separated from each other at the “floating” end, when earthed at one end only.

The requirement for earthing of the cable metal sheath, armour and braid, in 3.9.4 is not made with respect to earthing of equipment or consumers, but for the earthing of the cable itself.

Armour or braiding might be accepted as a PE- conductor for the equipment itself if cross section is sufficient and the cable type is constructed for that purpose.

For cables without an insulating sheath over the metal sheath or armour or braiding, the earthing of the cable itself may be carried out by fixing the cable to the hull constructions, or to parts that are welded or riveted to the hull constructions (metal to metal without paint or coating), by corrosion resistant clamps or metal clips.

3.9.5 Conductor ends (termination)

a) All conductor ends shall be provided with suitable pressured sockets or ferrules, or cable lugs if appropriate, unless the construction of the terminal arrangement is such that all strands are being kept together and are securely fixed without risk of the strands spreading when entering the terminals.

b) IEC 60228 Class 5 conductors shall be fitted with pressured ferrules as required by a).

c) Termination of high voltage conductors shall be made by using pressure based cable lugs unless the actual equipment has connection facilities for direct connection of the stripped conductor tip.

d) Spare cable conductors shall either be terminated or insulated.

3.10 Trace or surface heating installation requirements

3.10.1 General

a) Heating cables, tapes, pads, etc. shall not be installed in contact with woodwork or other combustible material. If installed close to such materials, a separation by means of a non-flammable material may be required.

b) Heat tracing shall be installed following the system documentation from the manufacturer.

c) Serial resistance heat tracing cables shall not be spliced.

d) Heat tracing cables shall be strapped to equipment and pipes using a heat resistant method that does not damage the cable.

e) Space between fixing points should be a maximum of 300 mm.

f) Where practicable and where exposed to weather, the cables shall pass through the thermal insulation from below, via a gland to avoid mechanical damage to the trace cable.

g) The trace cable system with feeder connection boxes, thermostats, etc shall be mounted to avoid or be protected against mechanical damage.

h) Flexible conduits should be used as mechanical protection for the feeder cable to the trace start junction box installed on the pipe.

i) Heat tracing cables shall be installed in such a way as to allow dismantling of joints and valves, instruments etc. without cutting or damaging the cable. Heat tracing cables shall be installed along the lower semi-circle of the pipes.

j) The outside of traced pipes thermal insulation or protective cladding shall be clearly marked at appropriate intervals to indicate the presence of electric tracing of surface heating equipment.

k) Trace circuits shall be readable marked (or identified) at both the switchboard and the field end, for fault finding purposes.

l) Circuits, which supply trace and surface heating, shall be provided with an earth fault circuit breaker.

Normally the trip current shall be 30 mA. Higher trip currents (maximum 300 mA) for the circuit breaker will be accepted if 30 mA is impossible, due to capacitive current leakage in the trace cable circuit.

4 Inspection and Testing

4.1 General

4.1.1 General

Before an installation is put into service or considered ready for operation, it shall be inspected and tested. The aim for this testing shall verify that the physical installation is correct. The installation shall be verified in accordance with relevant documentation. There shall be no hazard to personnel, no inherent fire hazard, and the installation shall function as required for the safe operation of the vessel. This also applies after modifications and alterations.

4.2 Equipment installation

4.2.1 Location and ingress protection

It shall be verified that all equipment is suitably installed with respect to ventilation, ingress protection and accessibility.

4.2.2 Escape routes

4.2.3 Switchboards more than 7 m long shall not form dead end corridors. Two escape routes shall be available as required by Sec.2/ 9.

4.3 Wiring and earthing

4.3.1 General

All equipment shall be verified with respect to proper installation with respect to external wiring and protective earthing.

4.3.2 Electrical test of high voltage cable after installation

After installation, with termination kit applied, high voltage cables shall be subject to one of the following alternative high voltage tests, with the voltage applied between the conductors and the screen:

a) When a DC voltage withstand test is carried out, the voltage shall be not less than:

- 1.6 (2.5 U0 + 2) kV for cables with U0 not exceeding 3.6 kV
- 4.2 U0 kV for cables with U0 in excess of 3.6 kV.

The test voltage shall be maintained for a minimum of 15 minutes.

b) A power frequency test at the normal operating voltage of the system, applied for 24 hours.

c) A power frequency test with the phase-to-phase voltage of the system applied between the conductor and the metallic screen or earth for 5 minutes. (IACS UR E11 7.2.6)

Guidance note:

The 5 minutes power frequency test is seldom used at the installation site due to the high reactive power needed for this method.

4.3.3 Insulation resistance testing of circuits and equipment

All outgoing power circuits from switchboards (cables and consumers) connected during installation shall undergo insulation resistance testing to verify its insulation level towards earth and between phases where applicable (i.e. switchboards assembled onboard.)

The insulation resistance tests (megger tests) shall be carried out by means of a suitable instrument applying a DC voltage according to Table 4.1.

Table 4.1: Test voltages and minimum insulation resistance

Rated voltage U_n (V)	Minimum test voltage (V)	Minimum insulation resistance (MΩ)
$Un \leq 250$	$2 \times U_n$	1
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	$(U_n /1000) + 1$
$7200 < U_n \leq 15000$	5000	$(U_n /1000) + 1$

4.4 Electric distribution and power generation

4.4.1 Testing of consumers

a) Function and load testing for essential and important equipment.

b) Consumers for essential and important functions shall be tested under normal operating conditions to ensure that they are suitable and satisfactory for their purpose.

c) Setting of protective functions shall be verified.

d) Consumers having their protective function (e.g. overload, short circuit and earth fault protection) wired up during installation, shall be tested for correct function. See also guidance note to 4.4.3.

4.4.2 Testing of electric distribution systems

a) Upon completion, the electric distribution system shall be subject to final tests at a sea trial.

b) The final test at sea assumes that satisfactory tests of main components and associated subsystems have been carried out.

c) The test program shall include tests of the distribution in normal conditions, and in any abnormal condition in which the system is intended to operate.

d) Start-up and stop sequences shall be tested, together with different operating modes. Also when controlled by automatic control systems when relevant.

e) Interlocks, alarms and indicators shall be tested.

f) All control modes shall be tested from all control locations.

4.4.3 Testing of generators and main switchboards

a) All generating sets together with their switchboard equipment (switchgear or protection and cabling) shall be run at the rated load until the exhaust temperature and cooling water temperature has stabilized and at least for the time specified in the rules. The following has to be verified:

- electrical characteristics in general and control of the generator itself
- engine room ventilation/air flow.

b) Dynamic tests such as voltage regulation, speed governing and load sharing shall be carried out to verify that voltage and speed regulation under normal and transient conditions is within the limits given in Sec.2/ 1, Sec.2/ 5, Sec.5/ 2.

c) The following tests shall be carried out:

- testing of overload protection
- reverse power protection
- overcurrent and short circuit protection
- other protection like: earth fault, differential, under-voltage, overvoltage (if applicable)
- synchronising systems.

Testing of overcurrent and short circuit protection: Secondary current injection is accepted as a method for verification of correct operation. For off the shelf moulded case circuit breakers and smaller MCBs with integrated protection units routine tested at the breaker manufacturer, testing of the protection functionality is generally not required. For other circuit breakers where testing at the switchboard manufacturer has been witnessed by ACS, and the circuit has not been wired up onboard, a verification of protection settings on board may be accepted.

4.4.4 Testing of voltage drop

Tests may be required to verify that the allowable voltage drop is not exceeded.

4.4.5 Testing of current distribution

Current distribution in parallel connected cables shall be verified. See Sec.2 10.6.1 d).

4.4.6 Testing of battery supplies

a) UPS systems and regular DC battery backed up power supply (transitional, emergency or clean power) systems serving essential or important functions shall be function tested for dip free voltage when feeding power is being switched off (black out simulation).

b) The battery backed up power supply system shall be run on expected load (in battery feeding mode) for a period determined by the requirements for the actual system and by the relevant rules This test is required in order to show the correct capacity of the systems.

c) Alarms shall be verified for correct function.

4.4.7 Testing of harmonic distortion

Tests may be required to verify that the level of harmonic distortion does not exceed the limits given in Sec.3.

4.4.8 Testing of independency between main and emergency system

It shall be verified that the main electrical power supply system is independent of the emergency electrical power supply systems. Before testing the main system, the emergency system including emergency switchboard and all battery systems powered from the emergency system shall be disconnected. The tests shall be performed under as realistic conditions as practicable.

The following shall be verified:

- black out start
- normal operation

4.4.9 Testing of dead ship recovery

Dead ship recovery, as required by Sec.2/ 2.2.4, shall be verified by testing. The tests shall be performed under as realistic conditions as practicable.

4.4.10 Redundancy tests

If separate emergency source of power is omitted in accordance with Sec.2/ 3.1.4 a selection of tests within each system analyzed in the FMEA shall be carried out. Specific conclusions of the FMEA for the different systems shall be verified by tests when redundancy or independence is required. The test procedure for redundancy shall be based on the simulation of failures and shall be performed under as realistic conditions as practicable.

4.4.11 Testing of semi-conductor converters

a) Semi-conductor converters for power supply shall be subject to complete function tests with intended loading onboard.

b) Functional tests of semi-conductor converters for motor drives shall be performed with all relevant ship systems simultaneously in operation, and in all characteristic load conditions.

Section 11 Hazardous Areas Installations

1 General

1.1 General

1.1.1 Reference to international standards, regulations and definitions

a) The requirements in this section are based upon the following standards: IEC 60079 part 0 to, and including part 19 regarding equipment construction. IEC 61892 part 7 “Mobile and fixed offshore units; Hazardous areas”, IEC 60092-502 “Special features-tankers”, and IMO MODU Code, for equipment selection and installation requirements.

b) For definitions related to installations in hazardous areas, see Sec.13/ 1.6.

2 Documentation

2.1 General

2.1.1 General

Electrical installations in hazardous areas shall be documented to comply with these rules.

2.1.2 Compilation of documented data

For electrical installations in hazardous areas, the information in Table 2.1 shall be compiled in a list or schedule of Ex-equipment (see Sec.1 with respect to any formalities for a classed vessel).

Table 2.1: Schedule of information on installations in hazardous areas

Information element	Description
Identification	Tag number or other reference used for marking of the specific equipment. This shall be the same in the documentation as on the physical installation
Equipment type	Descriptive title of equipment, e.g. “cable gland”, “fire detector”
Location of equipment	The relevant location of the equipment, according to the hazardous area classification drawing
Manufacturer	Name and nationality of manufacturer
Type designation	Manufacturers' type designation
Certification body, certificate number and type of protection	Identification of certifying body, the Ex certificate number and type of Ex protection
Special conditions	If the certificate number ends with “X” or “U”, compliance with the special conditions given in the certificate shall be stated
Is-circuit limits and values	Unless a system certificate is available defining the parameters for the complete intrinsically safe circuit, a system document shall be prepared containing barrier data and field instrument data for verification of compatibility between Is barrier and field equipment. Rated voltage and current of the field equipment shall not be exceeded. Maximum permissible inductance, capacitance or L/R ratio and surface temperature shall not be exceeded. The permissible values shall be taken from the associated apparatus documentation or the marking plate.
T_E -time	For motors and transformers located in a zone 1, certified as “increased safe”, Ex-e, the T_E -time shall be listed together with the release time of the associated over current protection
IP-rating	Ingress protection rating of the equipment

The IP rating should be listed so that correspondence with IP rating required according to the requirements in 4.1.2 is demonstrated.

3 Equipment Selection

3.1 General

3.1.1 General

For the selection of electrical equipment that shall be installed in hazardous areas the following requirements apply:

a) The Ex protection type shall be in accordance with any requirements for the area or zone in question, or as found in any applicable additional class notation.

b) Unless described in additional class notations, the hazardous area shall be categorised into hazardous zones in accordance with a relevant IEC standard, and the equipment shall be acceptable in accordance with 3.2 for installation in the hazardous zone category.

c) Electrical equipment and wiring shall not be installed in hazardous areas unless essential for operational purposes and when permitted by the relevant rules.

d) Gas group and temperature class of electrical equipment shall be in accordance with the requirements relevant for the gas or vapour that can be present (IEC 60092-502, 6.2.3, 6.2.4).

3.2 Ex protection according to zones

3.2.1 Zone 0

a) Electrical equipment installed into zone 0 shall normally be certified safe for intrinsic safety Ex-ia.

b) For zone 0 systems, the associated apparatus (e.g. power supply) and safety barriers shall be certified for Ex-ia application.

3.2.2 Zone 1

a) Electrical equipment installed into zone 1 shall be certified safe with respect to one of the following protection methods:

- Ex-i (intrinsic safe) category a or b
- Ex-d (flameproof)
- Ex-e (increased safety)
- Ex-p (pressurised)
- Ex-m (moulded)
- Ex-s (special protection).

b) Normally, Ex-o (oil filled) and Ex-q (sand filled) are not accepted. However, small sand filled components as i.e. capacitors for Ex-e light fixtures are accepted.

3.2.3 Zone 2

Equipment for zone 2 installation shall be in accordance with one of the following four alternatives:

a) Certified safe for zone 1 application.

b) Certified safe for zone 2 application.

c) Have a manufacturer conformity declaration stating that it is made in accordance with an Ex-n standard.

d) Documented by the manufacturer to be suitable for zone 2 installation. This documentation shall state compliance with a minimum enclosure protection of IP44, maximum temperature for internal or external surfaces according to the temperature class for the area and that the equipment contains no ignition sources during normal operation.

3.2.4 Battery rooms, paint stores, and welding gas bottle stores

a) Electrical equipment installed in battery rooms, lockers or boxes, paint stores or welding gas bottle stores, and in ventilation ducts serving such spaces shall be suitable for installation in zone 1 with the following requirements for gas group and ignition temperature:

- battery rooms: minimum gas group II C and temperature class T1
- paint stores: minimum gas group II B and temperature class T3
- welding gas bottle stores: minimum gas group II C and temperature class T2.

b) Cables routed through such spaces shall either be suitable for installation in hazardous area zone 1, or be installed in metallic conduit.

c) Areas on open deck within 1m of inlet and exhaust ventilation openings or within 3 m of exhaust outlets with mechanical ventilation are classified as zone 2.

d) Enclosed spaces giving access to such areas may be considered as non-hazardous, provided that:

- the door to the space is a gastight door with self-closing devices and without holding back arrangements (a watertight door is considered gastight)
- the space is provided with an acceptable, independent, natural ventilation system ventilated from a safe area
- warning notices are fitted adjacent to the entrance to the space stating that the store contains flammable liquids or gas.

e) Battery rooms and lockers or boxes shall be regarded as zone 2 hazardous areas with respect to access doors, lids or removable panels and possible interference with other rooms.

f) The fan mounted inside ventilation ducts shall be of non-sparking type.

3.3 Additional requirements for equipment and circuit design

3.3.1 Ex-e motors (increased safety)

Motors certified Ex-e shall, when installed in zone 1, have an overload or thermal protection that disconnects the motor before the TE-time is exceeded in a situation with locked rotor or some kind of machine stalling condition.

Ex-e equipment, TE-time

The TE -time is the time it takes for the motor, starting from normal operating temperature, to reach the temperature given by the temperature class of the Ex certification if the rotor is locked. The TE time is stated in the Ex-certificate for the motor.

3.3.2 Frequency converter driven Ex-e and Ex-d motors

a) Ex-e motors driven by a power converter are not accepted installed in zone 1 unless the converter and the motor are certified together. The certificate shall state allowed motor-converter combinations.

b) The requirement in a) applies also for Ex-d motors unless the motors are equipped with embedded RTDs in the windings and an over temperature trip device.

c) For Ex-n motors driven by converters, a conformity declaration as described in 3.2.3 is required. This declaration shall include information on accepted type of converter.

3.3.3 Ex-p equipment

a) For zone 1 installation, Ex-p protected equipment shall normally be certified safe as a complete system byan independent test institution (complete system being the equipment, the enclosure, the purging and the control system).

b) For zone 2 installation, Ex-p protected equipment may either be certified safe as for zone 1, or be verified safe by a competent person before taken into service. Such verification shall be documented in a verification report.

c) In zone 1 applications, automatic shutdown and or isolation of equipment inside enclosures will be required upon loss of pressurisation. If automatic shutdown increases the hazard to the vessel, then other protection methods shall be utilised for equipment that has to remain connected. In zone 2 applications, a suitable alarm at a manned control station for indication of loss of overpressure is accepted, instead of the automatic shutdown.

3.3.4 Ex-i circuits

a) All intrinsic safe circuits shall have a safety barrier in form of a Zener barrier or galvanic isolation certified safe for the application in front of the circuit part going into hazardous areas.

b) The complete intrinsic safe circuit shall not contain more than the maximum allowed, inductance, (Leq) and or capacitance (Ceq) than the barrier is certified for. The Leq and Ceq, shall be the total of the cable out to the hazardous area plus the values of connected equipment.

c) Both the safety barrier in the safe area, and the equipment installed in hazardous area shall be certified safe unless it is "simple apparatus".

Simple apparatus

a) A simple (non-energy storing) apparatus is an electrical component of simple construction with no, or low energy consumption or storage capacity, and which is not capable of igniting an explosive atmosphere. Normal maximal electrical parameters are 1.5 V, 100 mA and 25 mW. The component should not contain inductance or capacitance. Components such as thermocouples or passive switches are typical examples of simple, non-energy storing, apparatus.

b) Simple (non-energy storing) apparatus, when used in an intrinsically safe circuit, generally does not need to be certified safe, provided that such apparatus is constructed in accordance with IEC 60079-14, Part 14: "Electrical apparatus for explosive gas atmospheres".

3.3.5 Ex-d equipment

a) Ex-d enclosures and its flameproof joints shall not be installed nearer to a bulkhead or solid object than 10 mm for gas group II A, 30 mm for II B, and 40 mm for II C.

b) Flameproof joints shall be protected against corrosion with suitable non-hardening grease.

c) Gaskets can only be applied if originally fitted in the equipment from the manufacturer, and the equipment has been certified or tested with gaskets.

d) One layer of soft tape around the flameproof joint opening for corrosion protection is allowed for Ex-d enclosures installed in areas with gas groups II A and II B, but not II C areas.

e) Tape into (on the threads of) flameproof joints of threaded type, is not allowed.

f) Flameproof joints might be covered with a thin layer of paint on the outside. However, this is not accepted in II C areas.

4 Installation Requirements

4.1 General

4.1.1 General

For general installation requirements, see Sec.10. The following clauses are requirements especially for hazardous area installations.

4.1.2 Ingress protection

Ingress protection of equipment in relation to its location shall in general be as described in Sec.10, with the addition that the minimum IP degree of enclosures for Ex-n protected equipment is IP 44.

A comparison between the IEC based IP-rating and the NEMA types used in the USA is given in Table 4.1.

Table 4.1: Corresponding values for NEMA-Type and IP-rating

NEMA-Type	Description of NEMA-Type	IP-rating	Description of IP-rating
1	General purpose, indoor	11	Protection from solid objects larger than 55 mm
2	Suitable where severe condensation present	32	Protection against dripping water, spillage (not rain)
3	Weathertight against rain and sleet	54-55	Dustproof and resistant to splashing water (5) and rain(4). (normal outdoor weather proof)
3R	Less severe than NEMA 3	14	Protected from water only (rarely used in the IEC system)
4	Watertight. Resistant to direct water jet spray	56	Dustproof and heavy water jets (like on an open deck)
4X	Same as NEMA 4 although corrosion resistant, stainless or non-metallic	No equivalent	
5	Dust tight	52	Dustproof and resistant to dripping water (not rain)
6	Limited submersion in water	67	Protected against effect of immersion maximum 1 m (depth)
7	Explosion-proof. (Contains gaseous internal ignition)	No direct equivalent	Flameproof (Ex-d) works by the same principal
12	Dust tight and drip proof	52	Dustproof and resistant to dripping water (not rain)
13	Oil tight and dust tight. (Constructed with special gasketing to resist oil and liquid chemical penetration)	54-55	Dustproof and resistant to splashing water and rain. (normal outdoor weather proof)

4.2 Cable types, cabling and termination

4.2.1 Cable types

a) All cables installed in hazardous areas shall have an outer non-metallic impervious sheath.

b) Power and signal cables shall have a metallic braiding or armour between conductors and the non-metallic impervious sheath in the following zones and areas:

- zone 0
- zone 1
- all cables in hazardous areas on tankers.

c) Cables for intrinsically safe circuits shall have a common metallic screen or braiding. Multicore cables for Ex-i circuits shall have individual screened pairs unless all of the following is complied with:

- the cable shall be installed as fixed installation i.e. mechanically protected
- the circuit voltage shall be less than 60 V
- the cable shall be type approved or case by case.

4.2.2 Fixed cable installations

a) In zone 0 only cabling for Ex-ia circuits are allowed.

b) In zone 1 trough runs of cables other than the ones intended for Ex-equipment, shall be limited.

c) In zone 2, through runs of cables are accepted.

d) All metallic protective coverings of power and lighting cables passing through a hazardous zone, or connected to apparatus in such a zone, shall be earthed at least at their ends. The metallic covering of all other cables shall be earthed at least at one end.

4.2.3 Flexible cables

a) Flexible cables for non-intrinsically safe circuits shall be limited in hazardous areas and shall not be used permanently in zone 1.

b) Fixed installation with short flexible cable supported from connection boxes to equipment will be accepted into zone 2.

4.2.4 Penetrations of bulkheads and decks

Cable penetrations through bulkheads and decks shall be gas tight, and shall be of an approved type when used as sealing between zones or between hazardous areas and non-hazardous areas.

4.2.5 Cable entrance into equipment

a) In the case of direct entry into an Ex-d enclosure a certified safe gland shall be applied according to the following instructions:

- Zone 1: Either barrier or compound filled type of gland shall be used, or a rubber compression type gland might be used provided it is not a II C area, and the Ex-d internal volume is below 2 dm3.
- Zone 2: Both barrier or compound filled type and compression type gland is accepted.

b) For Ex-e, Ex-n and general non-sparking equipment the cable gland shall maintain the required IP-rating for the enclosure in question.

c) Unused openings for cable glands shall be blanked off by suitable plugs according to the equipment's Exprotection method. For Ex-e and Ex-n type of protection, the sealing plug shall maintain the required IP-rating for the enclosure in question. For Ex-d equipment, with direct entry, the sealing plug shall be certified safe (Ex-d) for the relevant application.

4.2.6 Termination and wiring inside Ex-e and Ex-d enclosures

a) Only one conductor is allowed to be connected into one Ex-e terminal.

b) In certified empty Ex-e enclosures, only the maximum amount of wiring and equipment stated in the certificate shall be installed within the enclosure.

c) All components inside an Ex-e enclosure shall be certified safe with protection Ex-e, -d, -m or other approved method for zone 1 application.

d) Certified empty Ex-d (flameproof boxes) shall have a final certificate taking into account the equipment installed within the Ex-d enclosure during installation.

4.2.7 Intrinsically safe circuit wiring and termination

a) The braid, armour or collective screen provided in intrinsically safe circuits shall be connected to the local earth at both ends, and might also be earthed at intermediate junction boxes or panels where relevant.

Where the bonding of the braiding, armour or screen at the field end is not practical, it may be earthed at the safe end only.

b) The individual screen, when provided, of single pair or multi pair cable, shall be connected to earth in safe area at the barrier end only. In hazardous area, the inner screen shall be properly insulated or terminated. If there is special reason to connect the inner screen to earth at both ends, then this might be accepted based on the explanation in IEC 60079-14 sec. 12.2.2.3.

c) Where the installation has separate earth bars for protective earth, instrument earth and intrinsically safe earth, these bars shall be used accordingly.

d) Terminals for intrinsically safe circuits and terminals for non-intrinsically safe circuits shall be separated by a physical distance of 50 mm or a by an earthed metallic partition. Terminals for intrinsically safe circuits shall be marked as such.

e) Category Ex-ia- circuits intended for zone 0, and category Ex-ib-circuits shall not be run in the same cable.

f) Intrinsically safe circuits and non-intrinsically safe circuits shall not be carried in the same cable.

g) Inside cabinets, screened wiring of non-intrinsically safe circuits can be laid in the same channel or tray as screened intrinsically safe circuits. Unscreened conductors in intrinsically safe and non-intrinsically safe circuits do not need any separating distance provided that the parallel wiring length is below 1m, and that the intrinsically safe and non-intrinsically safe conductors are not laid in the same cable or wiring bundle or wiring channel. For lengths longer than 1 m, the conductors shall be run at least 50 mm apart, or with an earthed metallic partition between the conductors.

4.2.8 Special conditions in EX certificates

Verification and inspection of Ex certified equipment shall include checking that special conditions for safe use given in the certificates are compiled with.

Section 12 Electric Propulsion

1 General

1.1 General

1.1.1 Application

a) The technical requirements in this section are in addition to those in Sec.2 to Sec.11 and apply to propulsion systems, where the main propulsion is performed by some type of electric motor(s).

b) Prime movers for generators providing electric power for propulsion shall be considered as propulsion prime movers. Prime movers and associated instrumentation and monitoring shall comply with the rule requirements for propulsion prime movers. Associated speed governing and control shall be arranged as for auxiliary prime movers.

c) Prime movers that drive generators for the supply of power for vessel service only, are defined as auxiliary prime movers, even if they may be connected to the propulsion power system and thus contribute to propulsion power.

d) Local and remote control systems for electric propulsion machinery shall comply with main class rules.

e) For instrumentation and automation, including computer based control and monitoring, the requirements in this chapter are additional to those given in Ch.3.

Attention should be given to any relevant statutory requirements of national authority of the country in which the vessel shall be registered.

1.2 System design

1.2.1 System arrangement

a) Electrical equipment in propulsion lines, which have been built with redundancy in technical design and physical arrangement, shall not have common mode failures endangering the maneuverability of the vessel, except for fire and flooding, which are accepted as common mode failures.

b) Vessels having two or more propulsion motors and converters, or two electric motors on one propeller shaft, shall be arranged so that any unit may be taken out of service and electrically disconnected without affecting the operation of the others.

c) Vessels having only one propulsion motor will be accepted as being built with redundancy in technical design and physical arrangement, with respect to single failures, as long as the motor is equipped with two independent sets of armature windings. These sets shall not be laid in the same slots in the iron core.

d) Vessels having only one propulsion motor of non-self exciting type having armature windings as required by c), but only one common field winding will be accepted without further redundancy when equipped with more than one external exciter.

1.2.2 Ventilation and cooling

The general requirements in Sec.2 will normally imply that loss of ventilation or cooling to spaces or equipment with forced air-cooling, shall not cause loss of propulsion. Sufficient power necessary for manoeuvring shall be available after any single failure. Where the propulsion system is arranged in different lines with the associated equipment for power distribution to these lines arranged in different rooms, failure of ventilation or cooling shall only render one propulsion line out of operation. However, redundancy requirements for main class and relevant additional class notations shall be adhered to.

1.3 System capacity

1.3.1 Torque

a) The torque/thrust available at the propeller shaft shall be adequate for the vessel to be manoeuvred, stopped, or reversed when the vessel is sailing at full speed.

b) Adequate torque margin shall be provided to guard against the motor pulling out of synchronism during rough weather conditions or manoeuvres.

c) Sufficient run-up torque margin shall be provided to ensure a reliable start under all ambient conditions.

d) Required locked rotor torque shall be considered in view of the operation of the vessel.

For thrusters, a gear oil temperature of 0°C should be considered.

1.3.2 Overload capacity

The system shall have sufficient overload capacity to provide the necessary torque, power, and for AC systems reactive power, needed during starting, manoeuvring and crash stop conditions.

1.4 Electric supply system

1.4.1 Electric supply system

a) The electric distribution system shall comply with the requirements in Sec.2.

b) The required split of the main switchboard shall be by bus tie breaker(s) capable of breaking any fault current that might occur at the location where it is installed.

c) Frequency variations shall be kept within the limits given in Sec.2. During crash-stop manoeuvres, it will be accepted that voltage and frequency variations exceed normal limits, if other equipment operating on the same net is not unduly affected.

1.5 System protection

1.5.1 Automatic voltage regulator failure

Where a single failure in the generators' excitation systems may endanger the manoeuvrability of the vessel, provisions shall be made to monitor the proper operation of the excitation system. Upon detection of abnormal conditions, an alarm shall be given on the navigating bridge and in the engine control room and actions to bring the system into a safe operational mode shall be automatically executed.

An accepted action will be to automatically open the bus tie breaker in the main switchboard so that different sections of the main busbar work independently of reactive load sharing.

1.5.2 Overspeed and regeneration

a) When necessary, overspeed protection of propulsion motors shall be arranged, preventing the speed during manoeuvring or fault conditions to exceed the limits for which the machine has been designed.

b) Regenerated power shall not cause any alarms in the propulsion system, neither in planned operating modes nor during emergency manoeuvres. Where necessary, braking resistors for absorbing or limiting such energy shall be provided.

1.5.3 Motor excitation circuits

a) Circuit protection in an excitation circuit shall not cause opening of the circuit, unless the armature circuits are disconnected simultaneously.

b) For a motor with one excitation winding and two armature windings, a failure in one of the armature circuits, shall not entail disconnection of the excitation circuit in operation.

1.6 Control systems

1.6.1 General

The following control functions are part of the electric propulsion system:

- propulsion control
- power plant control.

1.6.2 Propulsion control

a) The electric propulsion system shall be equipped with means for “emergency propulsion control”. These means shall be understood as a method of controlling the equipment that constitutes the propulsion system.

These means shall be independent of the normal propulsion remote control system.

b) Failure of the remote propulsion control system shall not cause appreciable change of the thrust level or direction and shall not prohibit local control.

c) The normal propulsion remote control system shall include means for limiting the thrust levels when there is not adequate available power. This may be an automatic pitch or speed reduction.

d) The thrust shall not increase substantially in case of loss of an actual value signal from a discrete transmitter or loss of a reference value in the system.

e) Means for emergency stop of propulsion motors shall be arranged at all control locations. The emergency stops shall be independent of the normal stop, and separate for each propulsion line.

f) In case remote control of a propulsion drive is arranged for selecting other than the normal speed control mode (e.g. torque or power) the propeller thrust shall not change significantly as a consequence of selecting an alternative operating mode.

It is accepted that ahead and astern thrust output will be different due to the propeller characteristics.

It is accepted that an emergency stop system has common power supply for several propulsion motors, as long as each motor can be stopped by this system independently of the other motors, and as long as a single failure in this emergency stop system cannot cause loss of manoeuvrability.

1.6.3 Power plant control

a) When electric propulsion is utilised, the electric power generation and distribution system shall be equipped with an automatic control system having at least the following functions:

- ensure adequate power for safe manoeuvring is available at all times
- ensure even load sharing between on-line generators
- execute load tripping and/or load reduction when the power plant is overloaded
- ensure that adequate power for safe manoeuvring is available also if one running generator is tripped.

If necessary by tripping of non-essential consumers

- no changes in available power shall occur if the automatic control system fails, that is no start or stop of generators shall occur as an effect of a failure
- control the maximum propulsion motor output.

b) The control system shall initiate an alarm, to the operator, when adequate power is no longer available.

The control system may have a selector for transit or manoeuvre mode, enabling operation with different levels of reserve power in these two modes of operation.

1.6.4 Monitoring and alarms

a) Safety functions installed in equipment and systems for electric propulsion shall not result in automatic shut down unless the situation implies that the equipment is not capable of further functioning, even for a limited time. Automatic reduction of propulsion power is accepted.

b) Priming control shall not prevent blackout start, if arranged.

c) Shutdowns caused by a safety function shall, as far as possible, be arranged with a pre-warning alarm.

d) For installations with one propulsion motor having two separate armature windings, the converters shall be arranged for automatic restart if an excitation failure in the motor may cause shutdown of both propulsion converters.

e) Critical alarms for propulsion shall be relayed to the navigation bridge and displayed with separate warnings separated from group alarms.

f) Monitoring with alarm shall be arranged for:

- high temperature of cooling medium of machines and semi-conductor converters having forced cooling
- high winding temperature of all propulsion generators and motors
- loss of flow of primary and secondary coolants of machines and semi-conductor converters having closed cooling method with a heat exchanger, when this flow is not caused by the propulsion motor itself. Auxiliary contacts from motor starters may be used for this purpose
- lubricating oil pressure for machines with forced oil lubrication
- leakage of water-air heat exchanger for cooling of machines and semi-conductor converters
- earth fault for main propulsion circuits
- earth fault for excitation circuits. (This may be omitted in circuits of brushless excitation systems and for machines rated less than 500 kW)
- fuses for filter units, or for other components where fuse failure is not evident.

g) A request for manual load reduction shall be issued, visually and acoustically on the bridge, or an automatic load reduction shall be arranged in case of:

- low lubricating oil pressure to propulsion generators and motors
- high winding temperature in propulsion generators and motors
- failure of cooling in machines and converters.

High-high, or extreme high, temperatures may, when higher than the high alarm limit, cause shut down of the affected equipment. For redundancy requirements, see 1.2. Critical alarms for propulsion machinery are alarms causing automatic shutdown or load reduction of parts of the propulsion power.

1.6.5 Instruments

a) A temperature indicator for directly reading the temperature of the stator windings of generators and propulsion motors shall be located in the control room.

b) The following values shall be displayed in the control room or on the applicable converter:

- stator current in each motor
- field current in each motor (if applicable).

c) For each generator: A power factor meter or kVAr meter.

d) On the bridge and in the control room, instruments shall be provided for indication of consumed power and power available for propulsion.

e) At each propulsion control stand, indications, based on feedback signals, shall be provided for pitch or direction of rotation, speed, and azimuth, if applicable.

f) Indications as listed for control stands shall be arranged in the engine control room, even if no control means are provided.

When the rated power of semi-conductors is a substantial part of the rated power of the generators, it should be ensured that measurements are displayed in true root mean square values. Temperature indicators may be omitted for winding temperatures that are displayed on the alarm system display.

2 Verification

2.1 Survey and testing upon completion

2.1.1 Onboard testing

a) Upon completion, the electric propulsion system shall be subject to final tests at a sea trial.

b) The final test at sea assumes that satisfactory tests of all subsystems have been carried out.

c) The test program shall include tests of the propulsion plant in normal and abnormal conditions as well as crash stop manoeuvres.

d) Start-up and stop sequences shall be tested, also as controlled by the power management system, when relevant.

e) Safety functions, alarms and indicators shall be tested.

f) All control modes shall be tested from all control locations.

g) Required level of redundancy shall be verified through tests.

Section 13 Definitions

1 Definitions

1.1 General

1.1.1 Electrical installations

The term electrical installations is an all-inclusive general expression that is not limited to the physical installations. For physical installations, the wording, “installation of…” is used.

1.1.2 Normally

The term “normally”, or “normally not”, when used in these rules, shall basically be understood as a clear requirement in line with “shall”, or “shall not”. However, upon request, other designs may be accepted.

If the rules are used for a vessel classed by ACS, then the Society shall be requested, in writing, to accept a deviating design. A request giving the reasons for the design shall be submitted.

1.2 Operational conditions

1.2.1 Normal operational and habitable condition

Normal operational and habitable condition is a condition under which the vessel, as a whole, is in working order and functioning normally. As a minimum, the following functions shall be operational: Propulsion machinery, steering gear, safe navigation, fire and flooding safety, internal and external communications and signals, means of escape, emergency boat winches, anchor winches and lighting necessary to perform normal operation and maintenance of the vessel. Additionally, designed comfortable conditions for habitability, including; cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water. All utility systems for the listed functions shall be included.

1.2.2 Emergency condition

An emergency condition is a condition under which any services needed for normal operational and habitable conditions are not in working order due to the failure of the main electrical power system.

1.2.3 Dead ship condition

Dead ship condition is a condition that the entire machinery installation, including the power supply, is out of operation and that auxiliary services such as compressed air, starting current from batteries etc., for bringing the main propulsion into operation and for the restoration of the main power supply are not available

1.2.4 Blackout situation

Blackout situation occurs when there is a sudden loss of electric power in the main distribution system and remains until the main source of power feeds the system. All means of starting by stored energy are available.

1.3 Services

1.3.1 Essential services

a) Essential (primary essential) services are those services that need to be in continuous operation for maintaining the vessel's manoeuvrability in regard to propulsion and steering. Additional class notations may extend the term essential services. Such extensions, if any, can be found in the relevant rule chapters.

b) Examples of equipment and or systems for essential services:

- control, monitoring and safety devices or systems for equipment for essential services
- scavenging air blower, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and freshwater cooling water pumps for main and auxiliary engines
- viscosity control equipment for heavy fuel oil
- ventilation necessary to maintain propulsion
- forced draught fans, feed water pumps, water circulating pumps, condensate pumps, oil burning installations, for steam plants on steam turbine vessels, and also for auxiliary boilers on vessels where steam is used for equipment supplying primary essential services
- steering gears
- azimuth thrusters which are the sole means for propulsion or steering - with lubricating oil pumps, cooling water pumps
- electrical equipment for electric propulsion plant - with lubricating oil pumps and cooling water pumps
- pumps or motors for controllable pitch propulsion or steering propellers, including azimuth control
- hydraulic pumps supplying the above equipment
- electric generators and associated power sources supplying the above equipment.

1.3.2 Important services

Important (secondary essential) services are those services that need not necessarily be in continuous operation for maintaining for the vessel's manoeuvrability, but which are necessary for maintaining the vessels functions.

Important electrical consumers are electrical consumers serving important services. Electrical equipment necessary to fulfil requirements to additional class or service notations are to be considered important equipment.

a) Such extensions, if any, can be found in the relevant rule chapters.

b) Examples of equipment or systems for important services:

- anchoring system

- thrusters not part of steering or propulsion
- fuel oil transfer pumps and fuel oil treatment equipment
- lubrication oil transfer pumps and lubrication oil treatment equipment
- pre-heaters for heavy fuel oil
- seawater pumps
- starting air and control air compressors
- bilge, ballast and heeling pumps
- fire pumps and other fire extinguishing medium appliances
- ventilating fans for engine and boiler rooms
- ventilating fans for gas dangerous spaces and for gas safe spaces in the cargo area on tankers
- inert gas systems
- navigational lights and signals
- navigation equipment
- internal and external safety communication equipment
- fire detection and alarm system
- main lighting system
- electrical equipment for watertight closing appliances
- electric generators and associated power sources supplying the above equipment
- hydraulic pumps supplying the above equipment
- control, monitoring and safety systems for cargo containment systems
- control, monitoring and safety devices or systems for equipment to important services
- jacking motors
- water ingress detection and alarm system
- cargo pumping.

1.3.3 Emergency services

a) Emergency services are those services that are essential for safety in an emergency condition.

b) Examples of equipment and systems for emergency services:

- equipment and systems that need to be in operation in order to maintain, at least, those services that are required to be supplied from the emergency source of electrical power

- equipment and systems that need to be in operation in order to maintain, at least, those services that are required to be supplied from the accumulator battery for the transitional source(s) of emergency electrical power
- equipment and systems for starting and control of emergency generating sets
- equipment and systems for starting and control of prime movers (e.g. diesel engines) for emergency fire fighting pumps
- equipment and systems that need to be in operation for the purpose of starting up manually, from a “dead ship” condition, the prime mover of the main source of electrical power (e.g. the emergency compressor)
- equipment and systems that need to be in operation for the purpose of fire fighting in the machinery spaces. This includes emergency fire fighting pumps with their prime mover and systems, when required according to the rules.

c) Further requirements for emergency services are given in Sec.2.

1.3.4 Non-important services

Non-important services are those services not defined as essential or important; or those services that are not defined, according to 1.3.1, 1.3.2 and 1.3.3.

1.4 Installation

1.4.1 Short circuit proof installation

For low voltage installations, short circuit proof installation means one of the following methods:

- bare conductors mounted on isolating supports
- single core cables (i.e., conductors with both insulation and overall jacket) without metallic screen or armour or braid, or with the braid fully insulated by heat shrink sleeves in both ends
- insulated conductors (wires) from different phases kept separated from each other and from earth by supports of insulating materials, or by the use of outer extra sleeves
- double insulated wires or conductors.

1.5 Area definitions

1.5.1 Open deck

Open deck is a deck that is completely exposed to the weather from above or from at least one side.

1.6 Hazardous area

1.6.1 Area definitions

A hazardous area is an area (zones and spaces) containing a source of hazard and or in which explosive gas and air mixture exists, or may normally be expected to be present in quantities such as to require special precautions for the construction and use of electrical equipment and machinery.

Hazardous areas are divided into Zone 0, 1 and 2 as defined below.

- Zone 0

Area in which an explosive gas atmosphere is present continuously or is present for long periods.

- Zone 1

Area in which an explosive gas atmosphere is likely to occur in normal operation.

- Zone 2

Area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only.

1.6.2 Certified safe equipment

Certified safe equipment is equipment certified by an independent national test institution or competent body to be in accordance with a recognised standard for electrical apparatus in hazardous areas.

1.6.3 Marking of certified safe equipment

Certified safe equipment shall be marked in accordance with a recognised standard for electrical apparatus in hazardous areas. This includes at least:

- Ex-protection type and Ex certificate number
- gas and equipment group, according to Table 1.1
- temperature class, according to Table 1.2.

Comparison between the IEC based zone, NEC based divisions and ATEX equipment categories are given in Table 1.3.

Table 1.1: Equipment and gas groups

Gas groups (IEC surface industry = II)	Representative gas	NEC 500 (US surface industry = class 1)
II A	Propane	Group D
II B	Ethylene	Group C
II C	Hydrogen	Group B
II C	Acetylene	Group A

Table 1.2: Temperature classes

Temperature classes(equipment maximum temperature) IEC and EN norms	Ignition temperature of gas or vapour °C	Corresponding NEC (US) temperature classes
T1	Above 450	T 1
T2	Above 300	T 2*
T3	Above 200	T 3*
T4	Above 135	T 4*
T5	Above 100	T 5
T6	Above 85	T 6

* Intermediate values of temperature classes by letter marking ABCD exist.

Table 1.3: Divisions and zones

	Continuous hazard	Intermittent hazard	Hazard under abnormal conditions
NEC500-503	Division 1	Division 2	Division 3
IEC	Zone 0 (Zone 20 dust)	Zone 1 (Zone 21 dust)	Zone 2 (Zone 22 dust)
ATEX	Category 1	Category 2	Category 3

1.7 Sources of power, generating station and distribution

1.7.1 Main source of electrical power

A main source of electrical power is a source intended to supply electrical power to the main switchboard(s) for distribution to all services necessary for maintaining the vessel in normal operational and habitable conditions.

A generator prime mover and associated equipment is called "generators' primary source of power".

1.7.2 Emergency source of electrical power

An emergency source of electrical power is a source intended to supply the emergency switchboard and/or equipment for emergency services in the event of failure of the supply from the main source of electrical power.

Emergency source of electrical power may be generator(s) or battery(ies).

A generator prime mover and associated equipment is called "emergency generators' primary source of power".

1.7.3 Main electric power supply system

a) A main electric power supply system consists of the main source of electric power and associated electrical distribution. This includes the main electrical generators, batteries, associated transforming equipment if any, the main switchboards (MSB), distribution boards (DB) and all cables from generators to the final consumer.

b) Control systems and auxiliary systems needed to be in operation for the above mentioned systems or equipment are included in this term.

1.7.4 Emergency electric power supply system

a) An emergency electric power supply system consists of the emergency source of electric power and associated electrical distribution. This includes emergency generators, batteries, associated transforming equipment if any, the transitional source of emergency power, the emergency switchboards (ESB), emergency distribution boards (EDB) and all cables from the emergency generator to the final consumer.

b) A transitional source of power is considered to be part of the emergency electric power supply system.

c) Control systems and auxiliary systems needed to be in operation for the above mentioned systems or equipment are included in this term.

1.7.5 Main generating station

A main generating station is a space in which the main source of electrical power is situated.

1.7.6 System with high resistance earthed neutral

A system with high resistance earthed neutral is a system where the neutral is earthed through a resistance with numerical value equal to, or somewhat less than, 1/3 of the capacitive reactance between one phase and earth.

1.7.7 System with low resistance earthed neutral

A system with low resistance earthed neutral is a system where the neutral is earthed through a resistance which limits the earth fault current to a value of minimum 20% and maximum 100% of the rated full load current of the largest generator.

1.7.8 Conductor, core, wire, cable

a) A conductor is a part of a construction or circuit designed for transmission of electric current.

b) A core is an assembly consisting of a conductor and its own insulation.

c) A wire is an assembly consisting of one core where the insulation is at least flame retardant.

d) In electrical terms, a cable is an assembly consisting of:

- one or more cores
- assembly protection
- individual covering(s) (if any)
- common braiding (if any)
- protective covering(s) (if any)
- inner and/or outer sheath.

Additional un-insulated conductors may be included in the cable.

e) A cable may be either Class 2 or Class 5 as defined in IEC 60228. In a Class 2 cable the conductor is made up by a minimum number of strands. In a Class 5 cable the conductor is made up by many small strands with a maximum size according to IEC 60288.

1.7.9 Neutral conductor

A neutral conductor is a conductor connected to the neutral point of a system, and capable of contributing to the transmission of electric energy.

1.7.10 Batteries

a) Vented batteries are of the type where individual cells have covers, which are provided with an opening,through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere. Normally, these types of battery have wet electrolyte with the possibility to check and refill electrolyte levels and to take the specific gravity of the electrolyte with a hydrometer.

b) Valve-regulated batteries are of the type in which the cells are closed, but have an arrangement (valve) that allows the escape of gas if the internal pressure exceeds a predetermined value. Normally, these are dry type or gel type batteries, with no refill or maintenance of electrolyte possible. Battery variants, characterised as “sealed” or “hermetically sealed” should be regarded as similar to the dry types, unless other properties are confirmed. With valve regulated batteries, the amount of escaping gas is normally very low. However, in the case where a battery, of this type, has been abnormally or excessively charged, then the volume of escaping gases can be comparable with the vented types.

1.7.11 Voltage levels

The terminology used in these rules are as follows:

Safety voltage: rated voltage not exceeding 50 V AC or DC

Low voltage: rated voltages of more than 50 V up to and inclusive 1 000 V with rated frequencies of 50 Hz or 60 Hz, or direct-current systems where the maximum voltage does not exceed 1500 V

High voltage: rated voltages of more than 1 kV and up to and inclusive 15 kV with rated frequencies of 50 Hz or 60 Hz, or direct-current systems with the maximum voltage under rated operating conditions above 1 500 V.

1.7.12 Continuity of service

Condition for protective system and discrimination; after a fault in a circuit has been cleared, the supply to the healthy circuits is re-established.

1.7.13 Continuity of supply

Condition for protective system and discrimination; during and after a fault in a circuit, the supply to the healthy circuits is permanently ensured.

1.8 Switchboard definitions

1.8.1 Main switchboard (MSB)

a) A main switchboard is a switchboard directly supplied by the main source of electrical power or power transformer and intended to distribute electrical energy to the vessel’s services.

b) Switchboards not being directly supplied by the main source of power will be considered as main switchboards when this is found relevant from a system and operational point of view.

Normally, all switchboards between the main source of electrical power and (inclusive) the first level of switchboards for power distribution, to small power consumers, will be considered to be main switchboards (MSBs) (i.e. at least first level of switchboards for each voltage level used).

Cubicles for other system voltages attached to a main switchboard are considered part of the main switchboard.

1.8.2 Emergency switchboard (ESB)

a) An emergency switchboard is a switchboard, which in the event of failure of the main electrical power supply system, is directly supplied by the emergency source of electrical power and/or the transitional source of emergency power and is intended to distribute electrical energy to the emergency power consumers.

b) Switchboards not being directly supplied by the emergency source of power may be considered as emergency switchboards when this is found relevant from a system and operational point of view.

Normally all switchboards between the emergency source of electrical power and (inclusive) the first level of switchboards, for power distribution to small power consumers, will be considered to be emergency switchboards (ESBs) (i.e. at least one level of switchboards for each voltage level used).

1.8.3 Distribution board (DB) and emergency distribution board (EDB)

A distribution board or an emergency distribution board is any switchboard utilised for distribution to electrical consumers, but which is not considered as a main or emergency switchboard.

1.9 Components and related expressions

1.9.1 Definitions of words used in relation to electrical components and equipment

a) For definitions of terms related to switchgear and control gear, see IEC 60947-1 for low voltage, and IEC 60470 and IEC 60056 for high voltage equipment.

b) For assemblies, the following definitions are used in the rules:

- Control gear: A general term for devices used for controlling consumer equipment, e.g. by switching on and off, starting and stopping a motor, controlling a motor's speed.
- Electrical components: electrical units for use in electrical equipment. A component is ready made by a component manufacturer, for use by an equipment manufacturer. The term component is also used for smaller free-standing equipment like connection boxes, sensors, switches etc.
- Electrical equipment: A common term for electrical machines, transformers, switchboards, panels, assemblies, control units and other units made by components.
- Semi-conductor assembly: Electrical equipment that uses semi-conductors as the main active elements, for switching or conducting the main flow of power.
- Switchgear: A common term for devices used for making and breaking circuits, including auxiliary components such as for example short circuit and overcurrent relays, coils, etc.

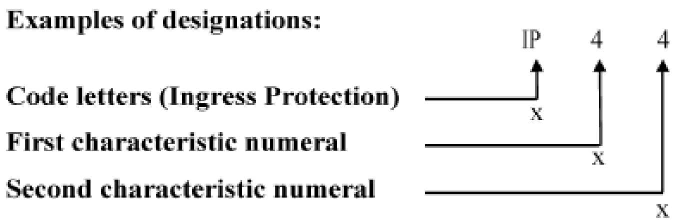
c) Tracking index is the numerical value of the proof voltage, in volts, at which a material withstands 50 drops without tracking, in accordance with IEC 60112 (i.e. a voltage value describing the isolating materials surface property to withstand tracking when wet.) Determination of the tracking index shall be done in accordance with the requirements in IEC 60112, and is normally done by type testing of the material by the manufacturer, before the material is available in the market.

1.9.2 Ingress protection of enclosures

Ingress protection of enclosures in regard to intrusion of particles and water, normally called IP rating, is defined as follows:

Table 1.3: Ingress protection of enclosures

First characteristic numeral	Protection against intrusion of particles and against accidental touching of live parts
0	Non-protected
1	Protected against solid objects greater than 50 mm
2	Protected against solid objects greater than 12.5 mm
3	Protected against solid objects greater than 2.5 mm
4	Protected against solid objects greater than 1.0 mm
5	Dust protected
6	Dust tight
Second characteristic numeral	Protection against intrusion of water
0	Non-protected
1	Protected against dripping water
2	Protected against dripping water when tilted up to 15º
3	Protected against spraying water from above up to 60º from vertical
4	Protected against splashing water
5	Protected against water jets
6	Protected against heavy seas
7	Protected against the effects of immersion
8	Protected against submersion (water depth to be given)



For further details see IEC 60529.

Appendix 1 List of Alarms and Monitoring Parameters

1 General

1.1 General

1.1.1 The alarms and monitoring requirements in the Rule text are listed in Table 1.1 which can be used as guidance. Switchboard instrumentation is not listed.

In case of any deviation between Table 1.1 and the Rule text, the Rule text shall apply.

Table 1.1: List of alarms and monitoring parameters of miscellaneous electrical equipment

System	Item	Indication Alarm Trip	Location indicated in the rules	Reference	Comment
1.0 Design principles	Failure in one of the power supplies for consumers with dual supply	A	MAS	Sec.2/ 6.1.1 c)	
	Failure in cooling unit in environmentally controlled spaces	A	MAS	Sec.2/ 1.1.2 b)	Note 1) IACS URE 19
1.1 Automatic operation of CB and start /stop diesel engines/ PMS	Control system power failure	A	MAS	Sec.2/ 8.2.1 b)	
	Starting failure of prime mover	A	MAS	Sec.2/ 8.2.2 a)	
	Frequency	LA/HA	MAS	Sec.2/ 8.2.1 b)	
	Voltage	LA/HA	MAS	Sec.2/ 8.2.1 b)	
	Excessive percentage difference in loads	HA	MAS	Sec.2/ 8.2.2 a)	
	Generator standby	IR		Sec.2/ 2.1.5 g)	
1.2Emergency generator / ESB	Prime mover for emergency generator not ready for start	IR		Sec.2/ 3.3.1 c)	
	When used in port: Monitoring and safety requirements of prime mover		MAS	Sec.2/ 3.3.4 c)	
	When used in port: Fuel oil supply tank level	LA	MAS	Sec.2/ 3.3.4 d)	
1.3 Battery / UPS systems	Charging fail Alternatively: battery being discharged)	A	MCS/MAS	Sec.2/ 4.1.3 Sec.7/ 1.2.11 f)	
	Ventilation fail	A	MCS	Sec.2/ 4.1.3 Sec.2 Table 9.2 Sec.2 Table 9.3	
	Automatic bypass in operation	A	MCS	Sec.7/ 1.2.11 f)	
	Operation of battery protection device	A	MCS	Sec.7/ 1.2.11 f)	

System	Item	Indication Alarm Trip	Location indicated in the rules	Reference	Comment
1.4 Navigation light	Failure in power supply	A	NB	Sec.2/ 6.2.3 a)	Note 2)
	Short-circuit	A	NB	Sec.2/ 6.2.4 c)	Note 2)
	Bulb failure	A	NB	Sec.2/ 6.2.4 c)	Note 2)
1.5 Protection	Insulation fault in distribution system	IL		Sec.2/ 7.1.2 a)	Note 3)
	Insulation fault in high voltage system without automatic disconnection by insulation fault	LA	MAS	Sec.2/ 7.1.2 a) and c)	Note 3)
	Loss of control voltage to protective functions	A	MAS	Sec.2/ 7.2.1 c)	
	Overload alarm for motors without overcurrent trip	A	MAS	Sec.2/ 7.5.1 d)	
	Activation of circuit protection in filter circuits	A	MCS	Sec.2/ 7.7.1	
1.6 Control Power distribution	Failure power supply to essential and important control and monitoring systems	A	MAS	Sec.2/ 8.1.2 c) Sec.2/ 6.3.6	
	Loss of voltage in the auxiliary power system in high voltage switchboards	A	MAS	Sec.4/ 2.2.3 c)	
1.7 Emergency stop	Failure in control power supply when arranged NO	A	MAS	Sec.2/ 8.5.1	
	Computer based system: System failure	A	MAS	Sec.2/ 8.5.1	
2.0 Cooling and anticondensation	Failure in mechanical cooling of electrical systems	A	MAS	Sec.3/ 4.2.1a)	Fail or Low flow
	Winding temperature in the cooled equipment for essential services	HA, IR	MAS	Sec.3/ 4.2.1 a)	
	Winding temperature in the cooled equipment for important services	HA	MAS	Sec.3/ 4.2.1 a)	
	Leakage alarm for water cooled heat exchangers	A		Sec.3/ 4.2.2 a) and b)	
4.0 Rotating machines	Temperature detectors embedded in stator winding	HA		Sec.5/ 1.3.1	Note 4)
5.0 Power transformers	Immersed transformers: Liquid level low	LA	A	Sec.6/ 1.2.2	
	Immersed transformers: Liquid temperature high	HA	A	Sec.6/ 1.2.2	
	Immersed transformers: Gas pressure high	SH		Sec.6/ 1.2.2	
	Immersed transformers: Interturn short circuit	SH		Sec.6/ 1.2.2	

System	Item	Indication Alarm Trip	Location indicated in the rules	Reference	Comment
6.0 Semiconductor Converters	Power supply failure	A	MAS	Sec.7/ 1.2.11 a)	
	Secondary side earth fault (IT distributions)	AL		Sec.7/ 1.2.11 b)	
	High conductivity of cooling liquid	AH		Sec.7/ 1.2.11 c)	Cooling liquid in contact with live parts
	Trip of units	A	MAS	Sec.7/ 3.1.2	
	Output voltage, frequency and current	IL		Sec.7/ 3.1.2	
7.0 Pressurized spaces and Ex-p	Loss of pressure to Ex-p (zone 2)	A	MCS	Sec.11/ 3.3.3 c)	
8.0 Electric propulsion	AVR-failure	A	NB & ECR (MAS)	Sec.12/ 1.5.1	
	Insufficient power for propulsion	A	NB	Sec.12/ 1.6.3 b)	
	Shut down pre warning alarm	A	NB	Sec.12/ 1.6.4 c)	
	Cooling medium temperature	HA	NB	Sec.12/ 1.6.4 f)	Note 5)
	Winding temperature of all propulsion generators and motors	HA	NB	Sec.12/ 1.6.4 f)	Note 5)
	Loss of flow of primary and secondary coolants	LA/A	NB	Sec.12/ 1.6.4 f)	Note5)& Note 7)
	Lubricating oil pressure	LA	NB	Sec.12/ 1.6.4 f)	Note 5)
	Water-air heat exchanger leakage	A	NB	Sec.12/ 1.6.4 f)	Note 5)
	Earth fault for main propulsion circuits	A	NB	Sec.12/ 1.6.4 f)	Note 5)
	Earth fault for excitation circuits	A	NB	Sec.12/ 1.6.4 f)	Note 5) and Note 8)
	Miscellaneous components	A		Sec.12/ 1.6.4 f)	Note 5) and Note 8)

IL = Local indication (presentation of values), in vicinity of the monitored engine component or system

IR = Remote indication (presentation of values), in engine control room or another centralized control station such as the local platform/manoeuvring console

A = Alarm activated for logical value

LA = Alarm for low value

HA = Alarm for high value

SH = Shut down with corresponding alarm. May be manually (request for shut down) or automatically executed if not explicitly stated above.

NB = Navigation bridge

MAS = Main alarm system

MCS = Main control station

Notes:

1) Applicable for cooling equipment in environmentally controlled spaces, where equipment with reduced ambient temperature tolerance is installed.
2) Alarms/indication required in WH only
3) Insulated or high resistance earthed systems
4) Applicable if rated output > 5000kW and all high voltage motors
5) Critical alarms shall be relayed to the navigation bridge and displayed with separate warnings separated from group alarms.
6) This may be omitted in circuits of brushless excitation systems and for machines rated less than 500 kW)
7) For machines and semi-conductor converters having closed cooling method with a heat exchanger, when this flow is not caused by the propulsion motor itself.
8) Fuses for filter units or for other components where fuse failure is not evident.

Chapter 3 Control and Monitoring Systems

Section 1 General Requirements

1 Classification

1.1 Rule applications

1.1.1 The requirements of this chapter shall apply to all control and monitoring systems required by the rules.

Additional requirements for specific applications will be given under rules governing those applications.

1.1.2 All control and monitoring systems installed, but not necessarily required by the rules, that may have an impact on the safety of main functions shall meet the requirements of this chapter.

1.2 Classification principles

1.2.1 Classification of control and monitoring systems shall generally be according to the following principles:

- plan approval
- certification of major units of equipment associated with essential and important control and monitoring systems
- on-board inspection (visual inspection and functional testing).

The plan approval normally includes case-by-case document assessment of each delivery, alternatively partly covered by type approval

1.2.2 Major units of equipment associated with essential and important control and monitoring systems, as specified in the rules, shall be provided with a product certificate unless exemption is given in a ACS issued Type Approval Certificate or the logic is simple and the failure mechanisms are easily understood.

The certification procedure normally consists of:

- assessment of certain manufacturer documentation
- visual inspection
- verification of performance according to functional requirements based on approved test programs
- verification of failure mode behaviour
- verification of implementation software quality plan covering life cycle activities, if applicable
- issue certificate.

Other control and monitoring systems, which when found to have an effect on the safety of the ship may be required to be certified.

Control and monitoring systems for the following systems shall be certified unless the above mentioned exemptions apply (in general, the certification requirements are given in the relevant application rule section, this list is for guidance only):

General :

water tight doors, side and stern doors

diesel engines, electronic engine management, steam turbines, gas turbines

propellers, water jets, propulsion thrusters, dynamic positioning thrusters

boilers, thermal-oil installations, oil fired water heaters,

power management

main alarm system, integrated control and monitoring systems

steering gears

Ro- Ro ship: bow doors monitoring

Oil Carriers: cargo tank level measurement, cargo tank overflow protection, cargo valves and pumps, flammable gas detection (permanent system only), inert gas, offshore loading and unloading

Chemical carriers: cargo tank level, cargo tank overflow protection, cargo valves and pumps, flammable gas detection (permanent system only), inert gas

Liquefied Gas Carriers: cargo tank level measurement, cargo tank overflow protection, cargo valves and pumps, flammable gas detection (permanent system only), inert gas, cargo and vapour pressure, oxygen indication equipment (permanent system only)

Offshore Service Vessels for Transportation of Low Flashpoint Liquids : cargo tank level measurement

Oil recovery ships: oil separating, fire detection, inert gas

Refrigerated Cargo ships: cargo hold temperature

Dynamic Positioning systems : dynamic positioning, independent joystick with auto heading

Gas fuelled engine installations: Gas control system, gas safety system, ventilation system.

1.2.3 The following control and monitoring systems are subject to certification, if installed, in addition to those specified in other sections:

- remote control of vessel main functions
- main alarm system
- integrated control and monitoring system.

1.3 Software and hardware change handling

1.3.1 The requirements in this section apply to software and hardware changes done after the certification, i.e. changes done after approval and issuance of the certificate.

1.3.2 Manufacturers or system suppliers shall maintain a system to track changes as a result of defects being detected in hardware and software, and inform users of the need for modification in the event of detecting a defect.

1.3.3 Major changes or extensions in hardware or software of approved systems shall be described and submitted for evaluation. If the changes are deemed to affect compliance with rules, more detailed information may be required submitted for approval and a survey may be required to verify compliance with the rules.

1.3.4 Software versions shall be identifiable as required in Sec.4.

1.3.5 When basic- or application software is changed on an approved control system, the following requirements apply:

- a procedure for software change handling shall be available on request, describing the necessary steps and precautions related to SW handling
- major modifications which may affect compliance with the rules shall be described and submitted to the society for evaluation before the change is implemented onboard
- no modification shall be done without the acceptance and acknowledgement by the ships responsible
- the modified system shall be tested and demonstrated for the ships responsible
- the modification shall be documented (including objective/reason for the change, description, authorization, test record, signatures, date, new incremented SW revision no)
- a test program for verification of correct installation and correct functioning of the applicable functions shall be available
- in case the new software upgrade has not been successfully installed, the previous version of the system shall be available for re-installation and re-testing.

1.3.6 If the control system is approved for remote software maintenance (i.e. from outside the vessel), the following requirements apply supplementary to 1.3.4:

- A particular procedure for the remote SW maintenance operation shall exist
- No remote access or remote SW modification shall be possible without the acceptance and
- acknowledgement by the ships responsible
- The security of the remote connection shall be ensured by preventing unauthorized access (e.g. password, and other means of verification) and by protecting the data being transferred (e.g. by encryption methodologies).
- Before the updated software is put into real-time use, the integrity of the new software shall be verified by appropriate means
- The remote session shall be logged in accordance with the above procedure for remote SW maintenance.

1.4 Assumptions

1.4.1 The rules of this chapter are based on the assumptions that the personnel using the equipment to be installed on board are familiar with the use of, and able to operate this equipment.

2 Definitions

2.1 General terms

2.1.1 Alarm is for warning of an abnormal condition and is a combined visual and audible signal, where the audible part calls the attention of personnel, and the visual part serves to identify the abnormal condition.

2.1.2 A control and monitoring system includes all components necessary for control and monitoring, including sensors and actuators. In this chapter, system is short for control and monitoring system. A system includes all resources required, including:

- the field instrumentation of one or more process segments
- all necessary resources needed to maintain the function including system monitoring and adequate self-check
- all user interfaces.

2.1.3 An essential control and monitoring system (hereafter called essential system) is a system which needs to be in continuous operation for maintaining the vessel's propulsion and steering. Examples of services are given in Ch.2, Sec.13. Additional class notations may extend the term essential services. Such extensions, if any, can be found in the relevant rule chapters.

The objective for an essential function is that it should be in continuous operation. However the rules do not in all respects fulfill this objective as single failures may lead to unavailability of a function.

2.1.4 An important control and monitoring system (hereafter called important system) is a system supporting services which need not necessarily be in continuous operation for maintaining the vessel's maneuverability, but which are necessary for maintaining the vessels functions the Rules for Classification of Ships, or other relevant parts of the rules. Additional class notations may extend the term important services. Such extensions, if any, can be found in the relevant rule chapters.

2.1.5 Non-important control and monitoring systems (hereafter called non-important systems) are systems supporting functions for which the Society has no requirements according to relevant definitions in the rules.

2.1.6 Field instrumentation comprises all instrumentation that forms an integral part of a process segment to maintain a function.

The field instrumentation includes:

- sensors, actuators, local control loops and related local processing as required to maintain local control and monitoring of the process segment
- user interface for manual operation (when required).

Other equipment items do not, whether they are implemented locally or remotely, belong to the field instrumentation. This applies to data communication and facilities for data acquisition and pre-processing of information utilised by remote systems.

2.1.7 A process segment is a collection of mechanical equipment with its related field instrumentation, e.g. a machinery or a piping system.

Process segments belonging to essential systems are referred to as essential.

2.1.8 An integrated system is a combination of computer based systems which are interconnected in order to allow common access to sensor information and/or command and control.

2.1.9 Operator station in an integrated system is a unit consisting of a user interface, i.e. UIDs and VDU, and interface controller(s).

2.1.10 User is any human being that will use a system or device, e.g. captain, navigator, engineer, radio operator, stock-keeper, etc.

2.1.11 Workstation is a work place at which one or several tasks constituting a particular activity are carried out and which provides the information and equipment required for safe performance of the tasks.

2.1.12 Equipment under control (EUC) is the mechanical equipment (machinery, pumps, valves, etc.) or environment (smoke, fire, waves, etc.) monitored and/or controlled by a control and monitoring system.

2.1.13 Independent systems: see Sec.2/ 1.2.1.

2.1.14 Redundancy is defined as two mutually independent systems that can maintain a function.

2.1.15 Remote control systems comprise all equipment necessary to operate units from a control position where the operator cannot directly observe the effect of his actions.

2.1.16 Back-up control systems comprise all equipment necessary to maintain control of essential functions required for the craft's safe operation when the main control systems have failed or malfunctioned.

2.1.17 Monitoring includes indication, alarming and/or protective safety functions.

Which of these elements a particular system contains depends upon the rule requirements for the application.

2.1.18 A protective safety system is a system that is activated on occurrence of predefined abnormal process condition to bring the process / EUC to a safe state. The safety action may be automatic or manual.

2.1.19 Engineers' alarm is an alarm system, which shall be provided to operate from the engine control room or the maneuvering platform, as appropriate, and shall be clearly audible in the engineers' accommodation. (SOLAS Ch. II-1/38)

The engineers' alarm is normally an integrated part of the extension alarm system, but may be a separate system.

2.2 Terms related to computer based system

2.2.1 Visual display unit (VDU) is normally a computer monitor, but may also be any area where information is displayed including indicator lamps or panels, instruments, mimic diagrams, light emitting diode (LED) display, cathode ray tube (CRT), and liquid crystal display (LCD).

2.2.2 User input device (UID) is any device from which a user may issue an input including handles, buttons, switches, keyboard, joystick, pointing device, voice sensor and other control actuators.

2.2.3 A software module is an assembly of code and data with a defined set of input and output, intended to accomplish a function and where verification of intended operation is possible through documentation and tests.

2.2.4 Basic software is the software necessary for the hardware to support the application software.

Basic software normally includes the operating system and additional general software necessary to support the general application software and project application software.

2.2.5 Application software is ship specific computer software performing general tasks related to the EUC being controlled or monitored, rather than to the functioning of the computer itself.

2.2.6 SW manufacturer is a manufacturer of equipment/systems in which programmable electronic systems are a component in the delivery.

2.2.7 A computer task is, in a multiprocessing environment, one or more sequences of instructions treated by a control program as an element of work to be accomplished by a computer.

2.2.8 Data communication links include point to point links, instrument net and local area networks, normally used for inter-computer communication. A data communication link includes all software and hardware necessary to support the data communication.

For local area networks, this includes network controllers, network transducers, the cables and the network software on all nodes.

2.2.9 A node in a network is a processing location and can be a computer or other device, such as a printer.

Every node has a unique network address.

3 Documentation

3.1 General

3.1.1 Overview documentation as listed in Table 3.1 is required submitted prior to commencement of approval work, applicable for ships with integrated systems installed.

Guidance note:

Typically submitted by yard based upon their detailed specification.

3.1.2 For document assessment, documentation listed in Table 3.2 is required submitted in order to adequately describe control and monitoring systems.

3.1.3 For a system subject to certification, documentation listed in Table 3.3 shall be available for the surveyor at testing at the manufacturer.

3.1.4 For on-board inspection, documentation listed in Table 3.4 is required submitted to survey station.

3.1.5 For control and monitoring systems subject to approval an operation manual and a maintenance manual are to be kept onboard.

3.1.6 The documentation shall be limited to describe and explain the relevant aspects governed by the rule requirements.

Documentation for a specific control and monitoring system should be complete (as required in Table 3.2) in one submittal.

A document may cover more than one instrumented system. A document may cover more than one documentation type.

Typically submitted by manufacturers based upon their project specific specification.

3.1.7 Symbols used shall be explained, or reference to a standard code given.

3.1.8 The documentation type number together with identification of the control and monitoring system can be used as a unique identifier for the document. The “T” indicates that the documentation type is required also for control and monitoring systems where type approved components or software modules are used.

Table 3.1: Documentation required submitted prior to commencing approval work

(typically submitted by yard based upon their detailed specification, applicable for ships with integrated systems installed)

Documentation type	Information element	Purpose	Where to
System philosophy	— the tasks allocated to each sub-system, divided between system tasks and manual tasks, including emergency recovery tasks — principles that will be used in the technical implementation of each system	Information	Approval centre
General arrangement for the ship	General ship information	Information	Approval centre
General arrangement for the main engine room	Main equipment layout	Information	Approval centre
Specification of main electro/ mechanical equipment	Electric power generation. Main propulsion line(s) with machinery and essential auxiliaries. Miscellaneous machinery or equipment (where control and monitoring systems are specified by other sections of the rules). The following shall be specified: — manufacturer and type — rating — number of — purpose	Information	Approval centre

Table 3.2: Documentation required for assessment
(project specific documentation typically submitted by manufacturers)

Documentation type	Information element	Purpose
Functional description (system requirement specification) See Guidance Note 1	— clear text description of the system configuration — clear text description of scope of supply and what is controlled and monitored and how — clear text description of safe state(s) for each function implemented — clear text description of switching mechanisms for systems designed with redundancy R0 — P&I/hydraulic/pneumatic diagrams if relevant.	Approval
System block diagrams	— a diagram showing connections between all main components (units, modules) of the system and interfaces with other systems.	Approval
User interface documentation	— a description of the functions allocated to each work and operator station — a description of transfer of responsibility between work and operator stations.	Approval
Power supply arrangement	— electrical supply: diagram showing connection to distribution board(s), batteries, converters or UPS.	Approval
Functional failure analysis Only where specifically requested by the ACS rules, or in special cases	The purpose of this functional failure analysis is to document that for single failures, essential systems will fail to safety and that systems in operation will not be lost or degraded beyond acceptable performance criteria when specified by the rules. The following aspects shall be covered: — a description of the boundaries of the system including power supply preferably by a block diagram — a list of items which are subject to assessment with a specification of probable failure modes for each item, with references to the system documentation — a description of the system response to each of the above failure modes identified — a comment to the consequence of each of these failures.	Approval
Failure mode and effect analysis where specifically required by ACS Rules See Guidance Note 2	A failure modes and effect analysis (FMEA) shall be carried out for the entire system. The FMEA shall be sufficiently detailed to cover all the systems' major components and shall include but not be limited to the following information: — a description of all the systems' major components and a functional block diagram showing their interaction with each other — all significant failure modes — the most predictable cause associated with each failure mode — the transient effect of each failure on the vessels position — the method of detecting that the failure has occurred — the effect of the failure upon the rest of the system's ability to maintain station — an analysis of possible common failure mode. Where parts of the system are identified as non-redundant and where redundancy is not possible, these parts shall be further studied with consideration given to their reliability and mechanical protection. The results of this further study shall be submitted for review.	Approval

Documentation type	Information element	Purpose
List of control & monitored points	A list and or index identifying all input and output signals to the system as required in the rules, containing at least the following information: — service description — instrument tag-number — system (control, safety, alarm, indication) — type of signal (digital / analogue input / output).	Approval
Circuit diagrams	— for essential hardwired circuits (for emergency stop, shutdown, interlocking, etc.) details of input and output devices and power source for each circuit.	Approval
Test program for testing at the manufacturer	Description of test configuration and test simulation methods. Based upon the functional description, each test shall be described specifying: — initial condition — how to perform the test — what to observe during the test and acceptance criteria for each test. The tests shall cover all normal modes as well as failure modes identified in the functional failure analysis, including power and communication failures.	Approval
Data sheets with environmental specifications	— environmental conditions stipulated in Sec.5 for temperature, vibration, humidity, enclosure and EMC	Information

Guidance note 1:

If the control system is simple, does not contain programmable components and the functionality and failure mechanisms can be easily understood from submitted drawings, the textual part of the functional description may upon agreement be omitted.

Guidance note 2:

Where an overall ship FMEA is requested in the application rules, this FMEA is normally supplied by the yard, and often made by an independent FMEA supplier. The manufacturers of control systems related to the application (e.g. propulsion, steering, power management,) normally provide an FMEA covering their scope of delivery. Then these FMEAs from the control system manufacturers are supposed to be evaluated by the overall FMEA supplier with respect to the overall design intention, and the conclusions shell be incorporated into the overall FMEA.

Table 3.3: Documentation required available for the testing at the manufacturer

Documentation type	Information element	Purpose
Software quality plan, based upon life cycle activities	The software life cycle activities shall minimum contain procedures for: — software requirements specification — parameters data requirements — software function test: — parameter data test — validation testing — system project files stored at the manufacturer — software change handling and revision control.	Available for information at testing at the manufacturer.
Operation manual	A document intended for regular use on board, providing information as applicable about: — operational mode for normal system performance, related to normal and abnormal performance of the EUC — operating instructions for normal and degraded operating modes — details of the user interface — transfer of control — redundancy — test facilities — failure detection and identification facilities (automatic and manual) — data security — access restrictions — special areas requiring user attention — procedures for start-up — procedures for restoration of functions — procedures for data back-up — procedures for software re-load and system regeneration.	Available for information at testing at the manufacturer.
Installation manual	A document providing information about the installation procedures. Available for information at testing at the manufacturer.	Available for information at testing at the manufacturer.
Maintenance manual	A document intended for regular use on board providing information about: — maintenance instructions — fault identification and repair — list of the suppliers' service net.	Available for information at testing at the manufacturer.

Table 3.4: Documentation required for on-board inspection, typically supplied by the yard

Documentation type	Information element	Purpose
Test program for quay and sea trials	A description of all tests that shall be carried out at the quay or at sea trial including: — initial condition — what to test — how to perform the test — acceptance criteria for the test.	Approval at local ACS station

3.2 Type approved products

3.2.1 For type approved components or software modules, reference shall be made to the type approval certificate number, the manufacturer's name and product type identification.

Documentation that has been approved during the type approval process should not be submitted, unless it has been revised or when asked for in the certificate.

3.2.2 For type approved systems, where different options exist for the configuration, the type approval certificate shall be completed with information about the components and software modules that are incorporated.

3.3 Plans and particulars

3.3.1 Plans for control and monitoring the following systems shall be submitted when mandatory and/or installed, as applicable, found in the respective parts of the rules.

The following shall in addition be documented, if installed:

- remote control of vessel main functions
- main alarm system
- integrated control and monitoring system
- engineers alarm.

Note: List taken from respective parts of the rules

Water tight doors, side and stern doors, water leakage monitoring.

Main and auxiliary engines, gas turbines, steam turbines.

Shafting, clutches/elastic couplings.

Propeller/water jets, thrusters.

Valves and pumps, remote control.

Boilers, thermal-oil installations, incinerators, oil fired water heaters.

Power management system

Remote control of vessel main functions, main alarm system, integrated control and monitoring system, engineers' alarm

Steering gear

Bow doors monitoring, fire doors, water ingress detection system, ventilation, container refrigerating.

Cargo and vapour temperature, cargo tank level, cargo tank overflow protection, cargo valves and pumps, flammable gas detection system (permanent system only), inert gas, offshore loading and unloading, oil discharge.

Cargo tank oil/water interface detection, cargo and vapour temperature, cargo tank level, cargo tank overflow protection, cargo valves and pumps, flammable gas detection system (permanent system only), inert gas.

Cargo and vapour temperature, cargo tank level, cargo tank overflow protection, cargo valves and pumps, cargo and vapour pressure, emergency shut-down system, Flammable gas detection system (permanent system only), inert gas, oxygen indication equipment (permanent system only).

4 Tests

4.1 General

4.1.1 All tests shall be according to test programs approved by the Society.

4.1.2 Tests in the presence of a ACS surveyor according to 4.2, 4.3 and 4.4 shall be performed at the manufacturers works.

4.1.3 The following shall be evaluated during test of computer based system:

- tools for system set-up and configuration of the EUC
- implementation of software quality plan, see also Sec.4/ 2.2.

4.1.4 The tests and visual examinations shall verify that all relevant rule requirements are met. The tests are only to cover requirements given by these rules. The test programs shall specify in detail how the various functions shall be tested and what shall be observed during the tests.

4.1.5 Failures shall be simulated as realistically as possible, preferably by letting the monitored parameters exceed the alarm and protective safety limits. Alarm and protective safety limits shall be checked.

4.1.6 It shall be verified that all automatic control functions are working satisfactorily during normal load changes.

4.2 Software module testing

4.2.1 Documentation of compliance with software module testing according to requirements for software quality plan as described in Sec.4/ 2.2 shall be available in connection with survey at manufacturers' works.

4.3 Integration testing

4.3.1 Integration tests include integration of hardware components into hardware units and integration of software modules in the same hardware unit.

4.3.2 Integration tests shall be done with the actual software and hardware to be used on board and shall include:

a) Hardware tests

- hardware failures.

b) Basic software tests

- basic software failures.

c) Application software tests.

d) Function tests of normal system operation and normal EUC performance, in accordance with the rules.

Function tests are also to include a degree of performance testing outside of the normal operating parameters.

e) User interface tests.

The tests may be done on a representative test system if the computer hardware is type approved.

4.4 System testing

4.4.1 System tests shall include the entire system, integrating all units. The tests may also include several systems.

4.4.2 System tests shall be done with the software installed on the actual systems to be used on board, interconnected to demonstrate the functions of the systems with several units and / or the functions of several systems.

The tests may be done on a representative test system if the computer hardware is type approved.

4.4.3 The tests shall include those tests which were not/could not be completed on unit level.

4.5 On-board testing

4.5.1 The tests shall include:

a) During installation the correct function of individual equipment packages, together with establishment of correct parameters for alarm, control and protective safety (time constants, set points, etc.).

b) During installation and sea trials, the correct function of systems and integration of systems, including the ability of the control systems to keep any EUC within the specified tolerances.

c) The correct protection and capacity of power supplies.

d) Back-up and emergency control functions for essential vessel systems.

4.5.2 The tests shall demonstrate that the essential vessel functions are operable on the available back-up means of control as required in the relevant application rules, and in a situation where the main control system is disabled as far as is practical.

4.5.3 The test program for harbour and sea trials shall be approved by the local ACS station.

4.5.4 The remote control system shall, if fitted, be tested at sea to demonstrate stable control and operation of the propulsion system with its necessary auxiliaries over the full operating range, and regardless of the type of propulsion. It shall be demonstrated that necessary ramping / controller functions are implemented to ensure that any operation of the manoeuvring levers do not cause shutdown, instability or damage to the propulsion machinery or power generating units.

4.5.5 If the machinery system is designed for different normal operational modes, e.g. dual fuel engines, the test described in 4.5.4 shall be run for each relevant mode of operation.

Section 2 Design Principles

1 System Configuration

1.1 General

1.1.1 Essential and important systems shall be so arranged that a single failure in one system or one unit cannot spread to another unit.

1.1.2 Failure of any remote or automatic control systems shall initiate an audible and visual alarm and shall not prevent normal manual control.

1.2 Field instrumentation

1.2.1 The field instrumentation belonging to separate essential process segments shall be mutually independent.

System B is independent of system A when any single system failure occurring in system A has no effect on the maintained operation of system B. A single system failure occurring in system B may have an effect on the maintained operation of system A.

Two systems are mutually independent when a single system failure occurring in either of the systems has no consequences for the maintained operation of the other system according to above.

1.2.2 When the field instrumentation of a process segment is common for several control and monitoring systems, and any of these systems are essential, failures in any of these control and monitoring systems shall not affect this field instrumentation.

1.2.3 When manual emergency operation of an essential process segment is required, separate and independent field instrumentation is required for the manual emergency operation.

1.2.4 Electronic governors shall have their power supply independent of other consumers and arranged with redundancy type R0. Governors for engines, other than those driving electrical generators, which keep the last position upon power failure, are regarded as fulfilling the redundancy type R0. Speed sensor cabling shall be mechanically well protected.

Electrical and electronic fuel injectors should be designed to permit the necessary functionality, in case of the most probable failures.

1.2.5 The accuracy of an instrument shall be sufficient to serve the functionality and safe operation of the EUC.

1.3 System

1.3.1 For an essential system having more than one process segment, failure in the field instrumentation of one process segment shall not result in failure for the remaining parts of the system.

1.4 Integrated system

1.4.1 Control shall only be available on workstations from where control is intended and access shall be provided via a command transfer system.

1.4.2 At least two operator stations shall be available at the main work station ensuring that all functions that may need simultaneous attention are available.

2 Response to Failures

2.1 Failure detection

2.1.1 Essential and important systems shall have facilities to detect the most probable failures that may cause reduced or erroneous system performance.

Failures detected shall initiate alarms.

2.1.2 The self-check facilities shall cover at least, but not limited to, the following failure types:

- power failures.

Additionally for essential systems,

- loop failures, both command and feedback loops (normally short circuit and broken connections)
- earth faults.

Additionally for computer based systems,

- communication errors
- computer hardware failures
- see also Sec.4.

2.2 System response

2.2.1 The most probable failures, e.g. loss of power or wire failure, shall result in the least critical of any possible new conditions.

Total loss of power to any single control system should not result in loss of propulsion or steering.

2.2.2 For redundant systems, any failure shall not cause an interruption of the process control that jeopardizes safe operation of the EUC. This applies also to the most time critical functions.

This typically applies to duplicated networks or controllers where a failure in one unit or network shall not lead to a downtime that may jeopardize the time response of the activation of a critical function, like e.g. a shutdown.

Section 3 System Design

1 System Elements

1.1 General

1.1.1 A system consists of one or several system elements where each system element serves a specific function.

1.1.2 System elements belong to the following categories:

- automatic control
- remote control
- alarm
- protective safety
- indications
- planning and reporting
- calculation, simulation and decision support.

1.1.3 Whenever automatic shutdown is required in the application rules, this function shall be implemented in a system unit that is mutually independent of the control and alarm systems related to the same Equipment Under Control (EUC). For an EUC where the automatic shutdown system is independent, control and alarm functions may be implemented in common system units.

When the application rules only require control and alarm functions for a EUC, these functions shall be implemented in either mutually independent system units or alternative in common system units if the system is redundant.

A redundant system shall, upon failure, have sufficient self diagnostics to effectively ensure transfer of active execution to the standby unit.

Exceptions from these general principles may be given if specified in the application rules for the EUC.

The independency requirement does not intend to prevent the different control-, alarm- and safety system units from communicating status information over e.g. a network, but each unit shall be able to perform its main functions autonomously, and not be dependent on the other control system units.

Redundancy in system design is in general not accepted as an alternative way to meet the requirement for independency between systems.

1.2 Automatic control

1.2.1 Automatic control shall keep process equipment variables within the limits specified for the process equipment (e.g. the machinery) during normal working conditions.

1.2.2 The automatic control shall be stable over the entire control range. The margin of stability shall be sufficient to ensure that variations in the parameters of the controlled process equipment that are expected under normal conditions, will not cause instability. The automatic control system element shall be designed so as to accomplish the function it shall serve.

1.2.3 Automatic control such as automatic starting and other automatic operations shall include provisions for manually overriding the automatic controls unless safe manual operation is not feasible. Failure of any part of such systems shall not prevent the use of the manual override.

1.2.4 In closed loop systems, feedback failures shall initiate an alarm, and the system shall enter the least critical of possible new conditions. This normally implies the system to either remain in its present state or move controlled to "zero" state.

1.2.5 Where indication of the automatically controlled parameter is required, the sensor for indication shall not be common with the sensor for feedback to the automatic control.

1.3 Remote control

1.3.1 At the remote work station being in command, the user shall receive continuous information on the effects of his orders.

1.3.2 One work station shall be designated as the main work station.

A work station may consist of multiple operator stations.

1.3.3 When control is possible from several work stations, only one workstation shall be in control at any one time.

1.3.4 Control shall not be transferred before being acknowledged by the receiving work station, unless the work stations are located close enough to allow direct visual and audible contact. Transfer of control shall give an audible pre-warning.

1.3.5 The main work station shall be able to take control without acknowledgement, but an audible warning shall be given at the work station that relinquishes control. The action for taking control shall not be the same as the normal control action.

1.3.6 Means shall be provided to prevent significant alteration of process equipment parameters when transferring control from one location to another, or from one means or mode of operation to another. If this involves manual alignment of control levers, indicators shall show how the levers shall be set to become aligned.

1.3.7 It shall be indicated at each alternative work station, when control is held.

1.3.8 Safety interlocks in different parts of the systems shall not conflict with each other.

Basic safety interlocks must be hardwired and shall be active during remote and local operation.

Hardwired safety interlocks should not be overridden by programmable interlocks.

1.4 Protective safety system

1.4.1 The protective safety system element shall be so designed that the most probable failures, e.g. loss of power supply or wire failure, result in the least critical of any possible new condition (fail to safety) taking into consideration the safety of the machinery itself as well as the safety of the vessel.

For essential systems which have a stopped unit as it's fail to safety principle, loop monitoring according to Sec.2/ 2.1 shall be provided and arranged such that loop failure initiates an alarm and do not stop the unit.

Where loop failure monitoring is not possible, a two out of two voting system may be accepted.

1.4.2 Protective safety actions shall give alarm at predefined work stations.

1.4.3 When the protective safety system element stops a unit, the unit shall not start again automatically.

1.4.4 When a protective safety system element is made inoperative by a manual override, this shall be clearly indicated at predefined workstations.

1.4.5 When the protective safety system element has been activated, it shall be possible to trace the cause of the safety action by means of central or local indicators.

1.4.6 When two or more protective safety actions are initiated by one failure condition (e.g. start of standby pump and stop of engine at low lubricating oil pressure), these actions shall be activated at different levels, with the least drastic action activated first.

An alarm shall be activated prior to a protective safety action, except when it is regarded as not being possible due to urgency.

1.5 Alarms

1.5.1 Alarm indicating devices shall be arranged such as to ensure attention of the responsible duty officer, e.g. machinery alarm indicating devices located in the normal working areas of the machinery space.

Several suitably placed low volume audible signal units should be used rather than a single unit for the whole area. A combination of audible signals and rotating light signals may be of advantage.

IMO resolution A.1021 (26) clause 9.5, requires that alarms and indicators on the navigation bridge should be kept at a minimum. Alarms and indicators not required for the navigation bridge should not be placed there unless permitted by the administration.

1.5.2 Visual indication shall be easily distinguishable from other indications by use of colour and special representation.

In view of standardizing, visual alarm signals should preferably be red. Special representation may be a symbol.

1.5.3 Audible signals used for alarms shall be readily distinguishable from signals indicating normal conditions, telephone signals, and noise.

1.5.4 Responsibility for alarms shall not be transferred before acknowledged by the receiving location.

Transfer of responsibility shall give audible pre-warning. At each alternative location, it shall be indicated when in charge.

1.5.5 Acknowledgement of alarms shall only be possible at the workstation(s) dedicated to respond to the alarm. In normal operation (also including unattended mode), it shall not be possible to transfer the acknowledgement rights from the machinery space / engine control room to a work station located outside the machinery space.

Alarm lists may be available on any workstation.

1.5.6 Alarms shall be annunciated by visual indication and audible signal. It shall be possible to see and distinguish different statuses of the alarms e.g. normal, active, unacknowledged, acknowledged and blocked.

Silencing and acknowledgement of alarms shall be arranged as follows:

Silencing the audible signal:

- Silencing the alarm shall cause the audible signal to cease, in addition to extinguishing any related light signals.
- The visual alarm indication shall remain unchanged.

Acknowledgement of an alarm:

- When an alarm is acknowledged the visual indication shall change. An indication shall remain if the alarm condition is still active.
- If the acknowledge alarm function is used prior to silencing of the audible signal, the acknowledgement may also silence the audible signal.

An active alarm signal shall not prevent indication of any new alarms, with related audible signal and visual indication. This requirement shall also apply for group alarms.

In case the alarms are presented on a screen, only visible alarms may be acknowledged.

1.5.7 Acknowledgement of visual signals shall be separate for each signal or common for a limited group of signals. Acknowledgement shall only be possible when the user has visual information on the alarm condition for the signal or all signals in a group.

1.5.8 Local audible signal for an alarm included in a centralised alarm handling system shall be suppressed when localised in the same workplace as the centralised alarm handling system.

1.5.9 Manual suppression of separate alarms may be accepted, when this is continuously indicated when suppressed.

1.5.10 Sufficient information shall be provided to ensure optimal alarm handling. The presence of active alarms shall be continuously indicated, and alarm text shall be easily understood.

1.5.11 The more frequent failures within the alarm system, such as broken connections to measuring elements, shall initiate alarm.

1.5.12 Interlocking of alarms shall be arranged so that most probable failures in the interlocking system, e.g. broken connection in external wiring, does not prevent alarms.

1.5.13 Inhibiting of alarm and protective safety functions in certain operating modes (e.g. during start-up) shall be automatically disabled in other modes.

1.5.14 It shall be possible to delay alarms to prevent false alarms due to normal transient conditions.

1.6 Indication

1.6.1 Indications sufficient to allow safe operation of essential and important functions shall be installed at all control locations from where the function can be accomplished. Alarms or pre-warnings are not considered as substitutes for indications for this purpose.

It is advised that indicating and recording instruments are centralised and arranged to facilitate watch-keeping, e.g. by standardising the scales, applying mimic diagrams, etc.

1.6.2 Adequate illumination shall be provided in the equipment or in the ship to enable identification of controls and facilitate reading of indicators at all times. Means shall be provided for dimming the output of any equipment light source which is capable of interfering with navigation.

1.6.3 Indication panels shall be provided with a lamp test function.

1.7 Planning and reporting

Planning and reporting functions are used to present a user with information to plan future actions.

1.7.1 Planning and reporting system elements shall have no outputs for real-time process equipment control during planning mode.

The output may however be used to set up premises for process equipment control, e.g. route plan used as input to an autopilot or load plan used as input for automatic or user assisted sequence control of the loading.

1.8 Calculation, simulation and decision support

1.8.1 Output from calculation, simulation or decision support modules shall not suppress basic information necessary to allow safe operation of essential and important functions.

Output from calculation, simulation or decision support modules may be presented as additional information.

2 General Requirements

2.1 System operation and maintenance

2.1.1 Start-ups and restarts shall be possible without specialised system knowledge. On power-up and restoration after loss of power, the system shall be restored and resume operation automatically.

2.1.2 Testing of essential systems and alarm systems shall be possible during normal operation. The system shall not remain in test mode unintentionally, and an active test mode shall be clearly indicated on the operator interface.

Automatic return to operation mode or alarm should be arranged.

2.2 Power supply requirements for control and monitoring systems

2.2.1 This part of the rules gives requirements for the power supply to different categories of control and monitoring systems. The principal requirements for the arrangement of the power supply are defined in Ch.2 Sec.2/ 1.1.1 and 6.3.

2.2.2 Essential control and monitoring systems shall be provided with two independent power supplies. This applies to both single and redundant control and monitoring systems.

For redundant control and monitoring systems, it is acceptable that each independent power supply are feeding both systems.

2.2.3 Redundant control and monitoring systems for important services, and control and monitoring systems required to be independent, shall be supplied by independent power supplies.

2.2.4 Redundant units in an integrated control and monitoring systems shall be provided with independent power supplies.

2.2.5 The following categories of control and monitoring systems shall be provided with uninterruptible power supply:

- Control and monitoring systems required to be operable during black-out.
- Control and monitoring systems required to restore normal conditions after black-out.
- Control and monitoring systems serving functions with redundancy type R0.
- Control and monitoring systems serving functions with redundancy type R1 - unless the control and monitoring system will be immediately available upon restoration of main power supply (i.e. no booting process).
- Control and monitoring systems for services with other redundancy types if the restoration time of the control and monitoring system exceeds the corresponding allowed unavailable time.
- Certain control and monitoring systems where specific requirements for stand-by power supply are given.

The capacity of the stored energy providing the uninterruptible power shall be at least 30 minutes, unless otherwise specified.

2.2.6 If the user interface is required to be duplicated, the requirement for independent power supplies also applies to the user interface. If uninterruptible power supply is required for the control system, this also applies to at least one user interface at the dedicated work stations.

Section 4 Additional Requirements for Computer Based Systems

1 General Requirements

1.1 Assignment of responsibility when installing integrated systems

1.1.1 There shall be one named body responsible for the integration of the total integrated system. This body shall have the necessary expertise and resources enabling a controlled integration process.

The responsible body may be the yard, a major manufacturer or another competent body.

1.2 System dependency

1.2.1 Where a computer based system is part of an essential function, back-up or emergency means of operation shall be provided, which to the largest extent possible shall be independent of the normal control system, with its user interface.

1.3 Storage devices

1.3.1 The on-line operation of essential functions shall not depend on the operation of rotating bulk storage devices, such as hard discs.

This does not exclude the use of such storage devices for maintenance and back-up purposes.

1.3.2 Software and data necessary to ensure satisfactory performance of essential and important functions shall normally be stored in non-volatile memory (e.g. EPROM, EEPROM or FLASH). Exception may be given for RAM with battery backup if the following three conditions are met:

- low battery voltage results in an alarm or visual indication detectable by routine inspections
- battery can easily be replaced by crew personnel without danger of losing data
- battery failure has no influence on performance as long as normal power supply is maintained.

1.4 Computer usage

1.4.1 Computers serving essential and important functions shall only be used for purposes relevant to vessel operation.

1.5 System response and capacity

1.5.1 Systems used for control and monitoring shall provide response times compatible with the time constants of the related EUC (equipment under control).

The following response times are applicable for typical EUC on vessels:

Data sampling for automatic control purposes (fast changing parameters)	0.1 s
Data sampling, indications for analogue remote controls (fast changing parameters)	0.1 s
Other indications	1 s
Alarm presentations	2 s
Display of fully updated screen views	2 s
Display of fully updated screen views including start of new application	5 s

1.5.2 System start-up and system restoration after power failures shall take place with sufficient speed to comply with the maximum unavailable time for the systems concerned, reverting thereafter to a pre-defined state providing an appropriate level of safety.

1.5.3 System capacities shall be sufficient to provide adequate response times for all functions, taking the maximum load and maximum number of simultaneous tasks under normal and abnormal conditions for the EUC into consideration.

1.6 Temperature control

1.6.1 Wherever possible, computers shall not have forced ventilation. For systems where cooling or forced ventilation is required for keeping the temperature at an acceptable level, alarm for high temperature or maloperation of the temperature control function, shall be provided.

1.7 System maintenance

1.7.1 Integrated systems supporting one or more essential or important function shall be arranged to allow individual units to be tested, repaired and restarted without interference with the maintained operation of the remaining parts of the system.

1.7.2 Essential systems shall have diagnostic facilities to support finding and repairs of failures.

1.8 System access

1.8.1 Access to system set-up or configuration functions for the EUC shall be protected to avoid unauthorized modifications of the system performance. For screen based systems, tools shall be available to allow easy and unambiguous modification of configuration parameters provided modifications are allowable under normal operation.

As a minimum, this applies to:

- calibration data
- alarm limit modification
- manual alarm inhibiting.

The operator should only have access to the application(s) related to the operation of the functions covered by the system according to 1.3.1, while access to other applications or installations of such, should be prevented. Hot keys normally giving access to other functions or program exits (Alt+Tab, Ctrl+Esc, Alt+Esc, double-clicking in background, etc.) must be disabled on the UID's intended for normal operation.

1.8.2 Unauthorized access to the operation of essential and important systems, from a position outside of the vessel, shall not be possible. Refer to Sec.1/ 1.3.

2 System Software

2.1 Software requirements

2.1.1 Basic software on processor systems running application software belonging to different functions, shall have facilities for:

- running several modules under allocated priorities
- detection of execution failures of individual modules
- discrimination of faulty modules to ensure maintained operation at least of modules of same or higher priority.

2.1.2 Individual application software modules allocated as tasks under an operating system as specified above shall not perform operations related to more than one function. These modules shall be allocated priorities in accordance with the relative priority between the functions they serve.

2.1.3 When hardware belonging to inputs, outputs, communication links and user interface is configured to minimize the consequences of failures, the related software shall be separated in different computer tasks to secure the same degree of separation.

2.1.4 When calculation, simulation or decision support elements are used to serve essential functions, and a basic functionality can be maintained without these elements, the application software shall be designed so as to allow such simplified operation.

2.1.5 System set-up, configuration of the EUC and the setting of parameters for the EUC onboard shall take place without modification of program code or recompilation. The Society must be notified if such actions cannot be avoided.

2.1.6 Running application software versions shall be uniquely identified by number, date or other appropriate means. Modifications shall not be made without also changing the version identifier. A record of changes to the system since the original issue (and their identification) shall be maintained and made available to the surveyor on request.

- When the setting of parameters is equivalent to programming then version identification of these settings should be available. Version identification may be a check sum.
- For integrated systems, identification should be available in the system overview.
- For any screen based system, identification should be readily available on the VDU during normal operation.
- PROM's to be labeled.

2.2 Software development

2.2.1 All relevant actions under the development phase of a complex system software, shall be taken to ensure that the probability of errors that could occur in the program code is reduced to an acceptable level.

Relevant actions shall include at least:

- actions to ensure that the programming of applications is based on complete and valid specifications
- actions to ensure that software purchased from other parties has an acceptable track record and is subject to adequate testing
- actions to impose a full control of software releases and versions during manufacturing, installation onboard and during the operational phase
- actions to ensure that program modules are subject to syntax and function testing as part of the process
- actions to minimize the probability of execution failures.

Typical execution failures are:

- deadlocks
- infinite loops
- division by zero
- inadvertent overwriting of memory areas
- erroneous input data.

2.2.2 The actions taken to comply with 2.2.1 shall be documented and implemented, and the execution of these actions shall be retraceable. The documentation shall include a brief description of all tests that apply to the system (hardware and software), with a description of the tests intended made by sub-vendors, those carried out at the manufacturer's and those that remain until installation onboard.

2.2.3 When novel software is developed for essential systems, ACS “approval of the manufacturer” may be required, either prior to or as part of the actual product development.

3 Control System Networks and Data Communication Links

3.1 General

3.1.1 Any network integrating control and/or monitoring systems shall be single point of failure-tolerant. This normally implies that the network with its necessary components and cables shall be designed with adequate redundancy.

If the fault tolerance is based on other design principles, e.g. a ring net, the fault tolerance shall be documented specifically. The requirement applies to the network containing the integrated control and monitoring systems, and not eventual external communication links to single controllers, remote I/O or similar (e.g. a serial line to an interfaced controller) when such units otherwise can be accepted without redundancy.

3.1.2 The integrity and autonomy of each network segment within an integrated system shall be secured with appropriate network components, e.g. switches or routers. It shall be possible to protect each segment from unnecessary traffic on the remaining network, and each segment shall be able to work independent and with necessary operator interface.

Virtual networks (VLAN) are normally not accepted as an alternative to segmentation.

3.1.3 In a network integrating control and/or monitoring systems all network components controlling the network traffic and nodes communicating over the network shall be designed with inherent properties to prevent network overload at any time. This implies that neither the nodes nor the network components shall, be able to generate excessive network traffic or consume extra resources that may degrade the network performance.

This may imply that the nodes and network components shall have properties to monitor it's own communication through the network, and to be able to detect, alarm and respond in a predefined manner in case of an excessive traffic event.

3.1.4 The performance of the network shall be continuously monitored, and alarms shall be generated if malfunctions or reduced/degraded capacity occurs.

3.1.5 Cables and network components belonging to redundant networks shall be physically separated; by separate cable routing and installation of network components belonging to the redundant network in separate cabinets, power supply to such units included.

3.1.6 It shall be possible to maintain local control of machinery as required by rules independent of network status. This may imply that essential nodes hosting such control functions shall be able to work autonomously, and with necessary operator interface independent of the network.

To be demonstrated during sea-trial.

3.1.7 Internode signals shall reach the recipient within a pre-defined time. Any malfunctions shall be alarmed.

The 'pre-defined time' shall as a minimum correspond to the time constants in the EUC, which implies that the detection and alarming shall be initiated quickly enough to enable appropriate operator intervention to secure the operation of the EUC.

3.1.8 If the automation system is connected to administrative networks, the connection principle shall ensure that any function or failure in the administrative net can not harmfully affect the functionality of the control and monitoring system. The administrative functions shall be hosted in separate servers and shall, if at all necessary, have 'read only' access to the control network.

The “administrative network” in this connection may contain functions like e.g. report generation, process analysis, decision support etc. i.e. functions that by definition are not essential for vessel operation and not covered by the rules.

3.1.9 Functions being irrelevant for vessel operation (e.g. miscellaneous office- or entertainment-related functions) shall not be connected in any way to any control and monitoring system or utilise its network.

3.1.10 It shall not be possible for unauthorized personnel to connect equipment to the control and monitoring network or otherwise have access to such network.

This pertain to both communication onboard the vessel as well as remotely via external communication. Any access point to be clearly marked and shall be sufficiently secured e.g. by location with restricted access, a lockable device or password access.

3.1.11 Any powered network component controlling the network traffic shall automatically resume to normal operation upon restoration of power after a power failure.

3.1.12 All nodes in a network shall be synchronized to allow a uniform time tagging of alarms (and events) to enable a proper sequential logging.

3.1.13 The network shall be designed with adequate immunity to withstand possible exposure to electromagnetic interference in relevant areas.

This implies the use of suitable network media in areas exposed to high voltage equipment.

3.1.14 Systems allowing for remote connection (e.g. via internet), for e.g. remote diagnostics or maintenance purposes, shall be secured with sufficient means to prevent unauthorized access, and functions to maintain the security of the control and monitoring system. The security properties shall be documented. Refer also to Sec.1/1.3 for software change handling requirements.

Any remote access to the control system shall be authorized onboard. The system shall have appropriate virus protection also related to the possibility of infection via the remote connection.

If remote connection for e.g. the above purposes is possible, the function is subject to special considerations and case by- case approval.

3.1.15 The CCTV system (Closed Circuit Television) shall not be part of an integrated control system.

3.2 Network analysis

3.2.1 The control and monitoring network with its components, connected nodes, communication links (also external interfaces) shall be subject to an analysis where all relevant failure scenarios are identified and considered. The analysis may be in the form of e.g. an FMEA, and shall specifically focus on the integrity of the different network functions implemented in separate network segments as well as the main network components (switches, routers etc.)

The main purpose of the analysis shall identify possible failures that may occur in the network, identify and evaluate the consequences and to ensure that the consequences of failures are acceptable.

The analysis shall be performed in connection with the system design, and not after the system is implemented.

The requirement is basically applicable for all control and monitoring systems containing nodes connected on a common network. However, for simpler systems, the above requirement may be fulfilled by covering the most relevant failure scenarios in a test programme

3.3 Network test and verification

3.3.1 The network functionality shall be verified in a test where at least the following items shall be verified:

1) The main observations / items from the FMEA

2) Self diagnostics, alarming upon different network failures

3) Worst-case scenarios – network storm

4) Segment segregation – autonomous operation of segments

5) Individual controller node integrity – nodes working without network communication

6) Consequence of single cabinet failure.

Guidance note:

In order to simulate e.g. fire in a single cabinet / cubicle, and to verify that essential vessel functions are still available

3.4 Network documentation requirements

3.4.1 The following information related to the network properties shall be included in the documentation submitted for approval, (with reference to Sec.1, Table 3.2):

1) Topology and network details including power supply arrangement

2) Functional description, with special focus on interfaces

3) Identification of critical network components

4) Qualitative reliability analysis (e.g. FMEA)

5) Failure response test programme.

3.5 Wireless communication

3.5.1 Wireless communication links may be used in systems as defined by IACS UR E22.

3.5.2 The wireless equipment shall not cause interference to licensed users of the ISM frequency bands in the geographical areas where the ship shall operate. The radiated power level should be adjustable.

The wireless-equipment should be certified according to technical requirements established by applicable IEEE802 standards for operation within the ISM band. The user manual should identify any relevant spectrum and power restrictions for the ISM bands that may have been enforced by the authorities in the various states of relevance in the operating area of the vessel.

3.5.3 The wireless broadcasting shall operate in the radio bands designated for ISM.

Guidance note:

The industrial, scientific and medical (ISM) bands are located at 900 MHz (902-928 MHz), 2.4 GHz (2400-2483.5 MHz) and 5.8 GHz (5725-5850 MHz).

3.5.4 The wireless broadcasting shall sustain the anticipated electromagnetic environment on board and be tolerant towards interference from narrow-band signals.

The type of modulation used should be of the category “spread spectrum” and be in compliance with the IEEE 802 series. Direct Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS) are recognized standards for modulation.

If DSSS modulation is used and more than one access point (AP) may be active simultaneously, these APs should be physically separated and also use separate channels. The minimum processing gain should not be less than 10 dB.

3.5.5 The wireless system shall entail a fixed topology and support prevention of unauthorised access to the network.

The access to the network shall be restricted to a defined set of nodes with dedicated MAC (media access control) addresses.

3.5.6 In case more than one wireless system shall operate in the same area onboard and there is a risk of interference, a frequency coordination plan shall be made and the interference resistance shall be documented and then demonstrated on board.

3.5.7 The wireless equipment shall employ recognized international protocols supporting adequate means for securing message integrity.

The protocol should be in compliance with the IEEE 802 standard and the nodes should execute at least a 16-bit cyclic redundancy check of the data packets

3.5.8 In case any form of control signals or confidential data is transferred over the wireless network, data encryption according to a recognized standard shall be utilized.

Secure encryption schemes such as WiFi Protected Access (WPA) should be used to protect critical wireless data

3.5.9 The data handling and final presentation of information shall comply with rules and regulations being applicable to the information category.

Isochronous (real-time) or asynchronous (transmit-acknowledgment) transport will be required depending on the application.

3.6 Documentation of wireless communication

3.6.1 The following information related to the wireless communication shall be included in the documentation submitted for approval, (with reference to Sec.1 Table 3.2):

- functional description
- ISM certificate (IEEE802) from a license authority (typical flag state) or alternatively applicable test reports
- single line drawings of the WLAN topology with power arrangements
- specification of frequency band(s), power output and power management
- specification of modulation type and data protocol
- description of integrity and authenticity measures.

Section 5 Component Design and Installation

1 General

1.1 Environmental strains

1.1.1 Instrumentation equipment shall be suitable for marine use, and is normally to be designed to operate under environmental conditions as described in 2, unless means are provided to ascertain that the equipment parameters are not exceeded. These means are subject to approval on case-by-case basis.

1.1.2 Data sheets, sufficiently detailed to ensure proper application of the instrumentation equipment, shall be available.

1.1.3 Performance and environmental testing may be required to ascertain the suitability of the equipment.

1.2 Materials

1.2.1 Explosive materials and materials which may develop toxic gases, shall not be used. Covers, termination boards, printed circuit cards, constructive elements and other parts that may contribute to spreading fire, shall be of flame-retardant material.

Materials with a high resistance to corrosion and ageing should be used. Metallic contact between different materials should not cause electrolytic corrosion in a marine atmosphere. As base material for printed circuit cards, glass reinforced epoxy resin or equivalent should be used.

1.3 Component design and installation

1.3.1 Component design and installation shall facilitate operation, adjustment, repair and replacement. As far as practicable, screw connections shall be secured.

1.3.2 Mechanical resonances with amplification greater than 10 shall not occur.

1.3.3 Electric cables and components shall be effectively separated from all equipment, which, in case of leakage, could cause damage to the electrical equipment. In desks, consoles and switchboards, which contain electrical equipment, pipes and equipment conveying oil, water or other fluids or steam under pressure shall be built into a separate section with drainage.

1.3.4 Means shall be provided for preventing moisture (condensation) accumulating inside the equipment during operation and when the plant is shut down.

1.3.5 Differential pressure elements (dp-cells) shall be able to sustain a pressure differential at least equal to the highest pressure for the EUC (equipment under control).

1.3.6 Thermometer wells shall be used when measuring temperature in fluids, steam or gases under pressure.

1.3.7 The installation of temperature sensors shall permit easy dismantling for functional testing.

1.3.8 Clamps used to secure capillary tubes shall be made of a material that is softer than the tubing.

1.4 Maintenance, checking

1.4.1 Maintenance, repair and performance tests of systems and components are as far as practicable to be possible without affecting the operation of other systems or components.

Provisions for testing, (e.g. three-way cocks) shall be arranged in pipes connecting pressure switches/ transducers to EUC normally in operation at sea.

The installation should as far as possible be built up from easily replaceable units and designed for easy troubleshooting, checking and maintenance. When a spare unit is mounted, only minor adjustments or calibrations of the unit should be necessary. Faulty replacements should not be possible.

1.5 Marking

1.5.1 All units and test points shall be clearly and permanently marked. Transducers, controllers and actuators shall be marked with their system function, so that they can be easily and clearly identified on plans and in instrument lists. See also Ch.2, Sec.3/ 5.

Marking of test points with e.g alarm or tag numbers is acceptable as long as they can easily be identified in the alarm list or other documentation.

The marking of system function should preferably not be placed on the unit itself, but adjacent to it.

1.6 Standardizing

Systems, components and signals should be standardised as far as practicable.

2 Environmental Conditions, Instrumentation

2.1 General

2.1.1 The environmental parameters given in 2.2 to 2.11, including any of their combinations, represent “average adverse” conditions, which will cover the majority of applications on board vessels. Where environmental conditions will exceed those specified, special arrangements and special components will have to be considered.

Table 2.1: Parameter class for the different locations on board

Parameter	Class	Location
Temperature	A	Machinery spaces, control rooms,accommodation, bridge
	B	Inside cabinets, desks. etc. with temperature rise of 5°C or more installed in location A
	C	Pump rooms, holds, rooms with no heating
	D	Open deck, masts and inside cabinets, desks etc. with a temperature rise of 5°C or more installed in location C
Humidity	A	Locations where special precautions are taken to avoid condensation
	B	All locations except as specified for location A
Vibration	A	On bulkheads, beams, deck, bridge
	B	On machinery such as internal combustion engines, compressors, pumps, including piping on such machinery
	C	Masts
Electromagnetic compatibility (EMC)	A	All locations except as specified for bridge and open deck
	B	All locations including bridge and open deck

Components and systems designed in compliance with IEC environmental specifications for ships, Publication No. 60092-504 (1994), and for EMC, IEC Publication No. 60533, may be accepted after consideration.

Navigation and radio equipment shall comply with IEC Publication No. 60945, Marine navigational equipment - General requirements.

For EMC only, all other bridge-mounted equipment; equipment in close proximity to receiving antennas, and equipment capable of interfering with safe navigation of the ship and with radio-communications shall comply with IEC Publication No. 60945 (1996) Clause 9 (covered by EMC class B).

2.2 Electric power supply

2.2.1 Power supply failure with successive power breaks with full power between breaks.

- 3 interruptions during 5 minutes
- switching-off time 30 s each case.

2.2.2 Power supply variations for equipment connected to A.C. systems:

- combination of permanent frequency variations of ±5% and permanent voltage variations of ±10% of nominal
- combination of frequency transients (5 s duration) ±10% of nominal and voltage transients (1.5 s duration) ±20% of nominal.

2.2.3 Power supply variations for equipment connected to D.C. systems:

- voltage tolerance continuous ±10% of nominal
- voltage transients cyclic variation 5% of nominal.
- voltage ripple 10%.

2.2.4 Power supply variations for equipment connected to battery power sources:

- +30% to -25% for equipment connected to battery during charging
- +20% to -25% for equipment connected to battery not being charged
- voltage transients (up to 2 s duration) ±25% of nominal.

2.3 Pneumatic and hydraulic power supply

2.3.1 Nominal pressure ±20% (long and short time deviations).

2.4 Temperature

2.4.1 Class A:

Ambient temperatures +5°C to +55°C.

2.4.2 Class B:

Ambient temperatures +5°C to +70°C.

2.4.3 Class C:

Ambient temperatures -25°C to +55°C.

2.4.4 Class D:

Ambient temperatures -25°C to +70°C.

2.5 Humidity

2.5.1 Class A:

Relative humidity up to 96% at all relevant temperatures, no condensation.

2.5.2 Class B:

Relative humidity up to 100% at all relevant temperatures.

2.6 Salt contamination

2.6.1 Salt-contaminated atmosphere up to 1 mg salt per m3of air, at all relevant temperatures and humidity conditions. Applicable to equipment located in open air and made of material subject to corrosion.

2.7 Oil contamination

2.7.1 Mist and droplets of fuel and lubricating oil. Oily fingers.

2.8 Vibrations

2.8.1 Class A:

Frequency range 3 to 100 Hz.

Amplitude 1 mm (peak value) below 13.2 Hz.

Acceleration amplitude 0.7 g above 13.2 Hz.

2.8.2 Class B:

Frequency range 3 to 100 Hz.

Amplitude 1.6 mm (peak value) below 25 Hz.

Acceleration amplitude 4.0 g above 25 Hz.

2.8.3 Class C:

Frequency range 3 to 50 Hz.

Amplitude 3 mm (peak value) below 13.2 Hz.

Acceleration amplitude 2.1 g above 13.2 Hz.

2.9 Inclination

2.9.1 For ships, see Ch.1, Sec. 1.

2.10 Electromagnetic compatibility

2.10.1 The minimum immunity requirements for equipment are given in Table 2.2, and the maximum emission requirements are given in Table 2.3.

Electrical and electronic equipment should be designed to function without degradation or malfunction in their intended electromagnetic environment. The equipment should not adversely affect the operation of, or be adversely affected by any other equipment or systems used on board or in the vicinity of the vessel. Upon installation, it may be required to take adequate measures to minimize the electromagnetic noise signals.

Such measures may be in form of a list of electromagnetic noise generating- and sensitive equipment, and an estimate on required noise reduction, i.e. an EMC management plan. Testing may also be required to demonstrate electromagnetic compatibility.

2.11 Miscellaneous

2.11.1 In particular applications other environmental parameters may influence the equipment, e.g.:

- acceleration
- fire
- explosive atmosphere
- temperature shock
- wind, rain, snow, ice, dust
- audible noise
- mechanical shock or bump forces equivalent to 20 g of 10 ms duration
- splash and drops of liquid
- corrosive atmospheres of various compositions, (e.g. ammonia on an ammonia carrier).

2.11.2 Acceleration caused by the ship's movement in waves. Peak acceleration ±1.0 g for ships with length less than 90 m, and ±0.6 g for ships of greater length. Period 5 to 10 s.

Table 2.2 Minimum immunity requirements for equipment

Port	Phenomenon	Basic Standard	Performance criteria	Test value
A.C. power	Conducted low frequency interference	IEC 60945	A	50 - 900 Hz: 10% A.C. supply voltage 900 - 6000 Hz: 10 - 1% A.C. supply voltage 6 - 10 kHz: 1% A.C. supply voltage
	Electrical fast transient (Burst)	IEC 61000-4-4	B	2 kV 3)
	Surge voltage	IEC 61000-4-5	B	0.5 kV 1) /1 kV 2)
	Conducted radio frequency interference	IEC 61000-4-6	A	3 Vrms 3); (10 kHz)6) 150 kHz - 80 MHz sweep rate ≤ 1.5 x 10-3 decade/s 7) modulation 80% AM (1 kHz)
D.C. power	Conducted low frequency interference	IEC 60945	A	50 Hz - 10 kHz: 10% D.C. Supply voltage
	Electrical fast transient (Burst)	IEC 61000-4-4	B	2 kV 3)
	Surge voltage	IEC 61000-4-5	B	0.5 kV 1) /1 kV 2)
	Conducted radio frequency interference	IEC 61000-4-6	A	3 Vrms 3); (10 kHz)6) 150 kHz - 80 MHz sweep rate ≤1.5 x 10-3 decade/s 7) modulation 80% AM (1 kHz)
I/O ports, signal or control	Electrical fast transient (Burst) B	IEC 61000-4-4	B	1 kV 4)
	Conducted radio frequency interference	IEC 61000-4-6	A	3 Vrms 3); (10 kHz)6) 150 kHz - 80 MHz sweep rate ≤1.5 x 10-3 decade/s 7) modulation 80% AM (1 kHz)
Enclosure	Electrostatic discharge (ESD)	IEC 61000-4-2	B	6 kV contact/8 kV air
	Electromagnetic field	IEC 61000-4-3	A	10 V/m5) 80 MHz-2 GHz sweep rate ≤1.5 x 10-3 decade/s 7) modulation 80% AM (1 kHz)

1) line to line
2) line to ground
3) capacitive coupling
4) coupling clamp
5) special situations to be analysed
6) test procedure to be described in the test report
7) for equipment installed in the bridge and deck zone (EMC Class B) the test levels shall be increased to 10 Vrms for spot frequencies in accordance with IEC 60945 at 2/3/4/6.2/8.2/12.6/16.5/18.8/22/25 MHz. For screened cables, a special test set-up shall be used enabling the coupling into the cable screen.

Performance criterion A: The equipment under test (EUT) shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed as defined in the relevant equipment standard and in the technical specification published by the manufacturer.

Performance criterion B: The EUT shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed as defined in the relevant equipment standard and in the technical specification published by the manufacturer.

During the test, degradation or loss of function or performance that is self recoverable is however allowed but no change of actual operating state or stored data is allowed.

Table 2.3 Maximum emission requirements for equipment

Class	Location	Port	Frequency Range (Hz)	Limits
A	All locations except bridge and open deck	Enclosure (Radiated Emission)	150 k – 30 M 30 – 100 M 100 M – 2 G except: 156 – 165 M	80 – 50 dBμV/m 60 – 54 dBμV/m 54 dBμV/m 24 dBμV/m
		Power (Conducted Emission)	10 – 150 k 150 – 500 k 500 k – 30 M	120 – 69 dBμV 79 dBμV 73 dBμV
B	All locations including bridge and open deck	Enclosure (Radiated Emission)	150 – 300 k 300 k – 30 M 30 M – 2 G except: 156 – 165	M 80 – 52 dBμV/m 52 – 34 dBμV/m 54 dBμV/m 24 dBμV/m
		Power (Conducted Emission)	10 – 150 k 150 – 350 k 350 k – 30 M	96 – 50 dBμV 60 – 50 dBμV 50 dBμV

3 Electrical and Electronic Equipment

3.1 General

3.1.1 Switching of the power supply on and off shall not cause excessive voltage or other strains that may damage internal or external components.

3.1.2 Units requiring insulating resistance in cables and wiring higher than 200 kΩ are normally not to be used.

Exceptions can be made for special cable arrangements.

3.2 Mechanical design, installation

Circuits should be designed to prevent damage of the unit or adjacent elements by internal or external failures. No damage should occur when the signal transmission lines between measuring elements and other units are short circuited, grounded or broken. Such failures should lead to a comparatively safe condition (fail to safe).

The equipment should preferably function without forced cooling. Where such cooling is necessary, precautions should be taken to prevent the equipment from being damaged in case of failure of the cooling unit.

3.2.1 The components shall be effectively secured to avoid mechanical stressing of wires and soldered joints through vibrations and mechanical shock.

Components weighing more than 10 grams (0.35 oz), should not be fastened by their connecting wires only.

3.3 Protection provided by enclosure

3.3.1 Enclosures for the equipment shall be made of steel or other flame retardant material capable of providing EMC protection and satisfy the minimum requirements of Table 3.1. The required degree of protection is specified in IEC 60529 (International Electrotechnical Commission, Publication No. 60529). More detailed requirements for ingress protection of enclosure types related to location are given in Ch.2, Sec.10, Table 2.1.

Table 3.1 Minimum requirements for enclosures

Class	Location	Degree of protection
A	Control rooms, accommodation, bridge	IP 20
B	Machinery space	IP 44
C	Open deck, masts, below floor plates in machinery space	IP 56
D	Submerged application	IP 68

Automation equipment of class A and B that shall be in operation during emergency situations, located in areas exposed to wash down, should have IP 55 protection.

3.4 Cables and wires

3.4.1 Cables and wires shall comply with the requirements in Ch.2, Sec.9.

3.5 Cable installation

3.5.1 Cable installations shall comply with the requirements in Ch.2, Sec.10 and Ch.2, Sec.3/ 4.3.

3.6 Power supply

3.6.1 When using low voltage battery supply, the charging equipment, batteries and cables shall keep the voltage at equipment terminals within +25% to -20% of the nominal voltage during charging and discharging.

Provisions shall be made for preventing reverse current from the battery through the charging device.

3.6.2 Systems including a standby battery connected for continuous charging shall not be disturbed in any way by disconnection of the battery.

3.6.3 Battery installations shall be in accordance with Ch.2, Sec.10 /2.3.

3.6.4 Regulated rectifiers shall be designed for the variations in voltage and frequency stated in 2.

3.6.5 Different system voltages shall be supplied through different cables.

3.6.6 Terminal lists shall be clearly marked. Various system voltages shall be distinguished.

3.6.7 Uninterruptible power supplies shall be according to the requirements given in Ch.2, Sec.2/ 1.2.

3.7 Fibre optic equipment

3.7.1 Fabrication and installation of fibre optic cables shall comply with the requirements of Ch.2.

The construction of fibre optic devices is generally to comply with relevant specifications of IEC Publications.

3.7.2 Power budget calculation shall be used to:

- determine the length between I/O units,
- select components to obtain a safe reliable transmission system, and
- to demonstrate that adequate power reserve has been provided.

After installation, optical time domain reflectometry (OTDR) measurements for each fibre shall be used to correct and re-evaluate the power budget calculations.

3.7.3 The safety of personnel and operations shall be considered in the installation procedures. Warning signs and labels giving information to the operators shall be placed where hazard exists. Care must be taken to prevent fibres from penetrating eyes or skin.

It is advised to use equipment with 'built-in' safety, e.g. interlock the power to the light sources with the covers, possible to disconnect/lock parts of the system under service, screen laser beams.

Safe distance between the light source or fibre end and the eye of the operator may be determined by applying the formulae:

$L_{safe} = (P_n + 10)/2$

Safe distance: L (cm) ; Pn: Nominal power (mW)

3.7.4 Fibre optic systems using standard single- and multimode fibres to be used for intrinsically safe circuits in hazardous areas shall have a power level below 10 mW.

Section 6 User Interface

1 General

1.1 Application

1.1.1 The rules in this section apply for all main class vessels.

1.2 Introduction

1.2.1 The location and design of the user interface shall give consideration to the physical capabilities of the user and comply with accepted ergonomic principles.

1.2.2 This section gives requirements for the user interface to ensure a safe and efficient operation of the systems installed.

2 Workstation Design and Arrangement

2.1 Location of visual display units and user input devices

2.1.1 Workstations shall be arranged to provide the user with easy access to UIDs, VDUs and other facilities required for the operation.

2.1.2 The VDUs and UIDs shall be arranged with due consideration of the general availability parameters as shown in Figure2.1 and Figure2.2.

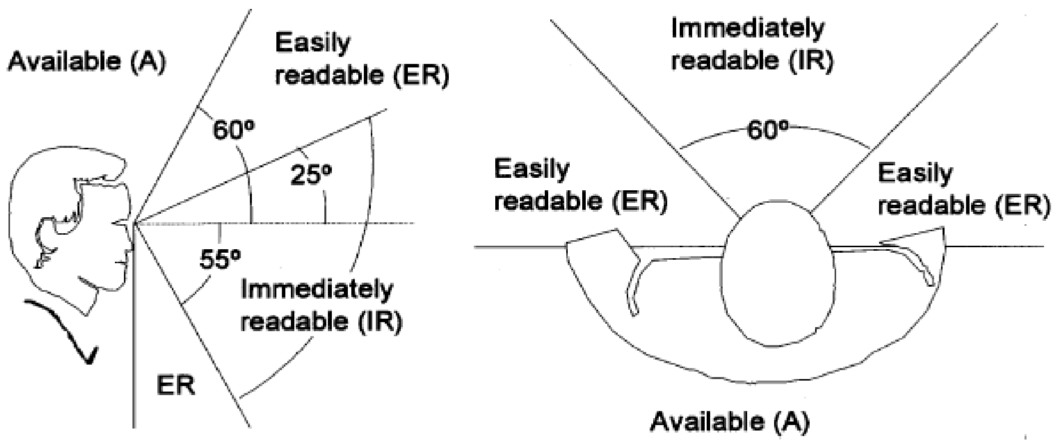


Figure 2.1: VDU arrangement parameters.

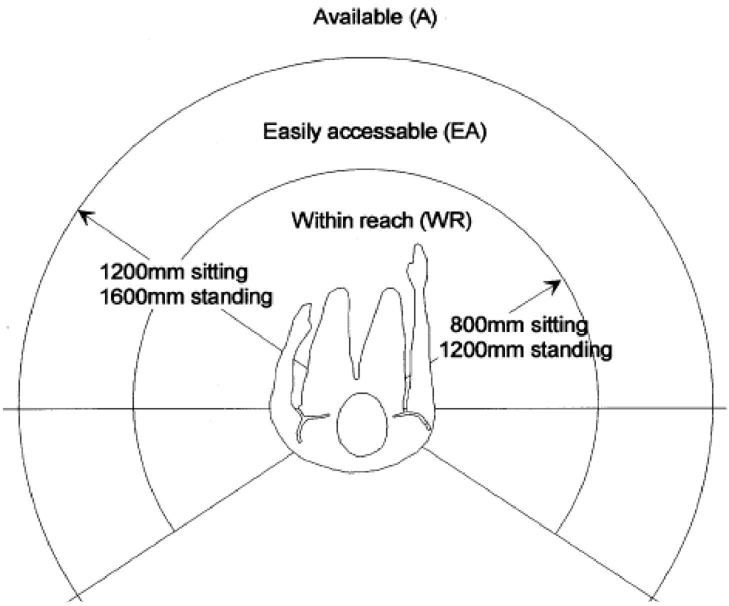


Figure 2.2: UID arrangement parameters.

2.1.3 UIDs and VDUs serving the same function shall as far as possible be arranged and grouped together.

3 User Input Device and Display Unit Design

3.1 User input devices

3.1.1 The method of activating a UID shall be clear and unambiguous.

3.1.2 The direction of UID movements shall be consistent with the direction of associated process response and display movement. The purpose shall be to ensure easy and understandable operation, such as:

- a side thruster lever to be arranged athwart ships
- a propulsion thruster lever shall be arranged according to the vessel response
- the thruster response shall correspond to the lever movement.

3.1.3 The operation of a UID shall not obscure indicator elements where observation of these elements is necessary for adjustments.

3.1.4 UIDs or combined UIDs/indicating elements shall be distinguishable from elements used for indication only.

3.1.5 UIDs shall be simple to use, and shall normally allow for one hand operation. The need for fine motoric movements shall be avoided.

3.1.6 The naming, numbering and tagging for the different main components shall be consistent on the applicable VDUs, UIDs and signboards.

3.2 Visual display units

3.2.1 The information presented shall be clearly visible to the user, and permit reading at a practicable distance in the light conditions normally experienced, where installed.

3.2.2 In order to ensure readability, the update frequency of VDUs shall be consistent with the operational use of the VDU and the accuracy requirement, if any, to the data displayed.

3.2.3 VDU letter type shall be of simple, clear-cut design.

3.2.4 Set points shall always be indicated at the location of the UID.

3.3 Colours

3.3.1 The use of colours shall be consistent. Red shall be reserved to indicate danger, alarm and emergency only. Colour coding of functions and signals shall be in accordance with Table 3.3.

Table 3.3: Colour coding

Function	Colour code
Danger, Alarm, Emergency	Red
Attention, Pre-warning, Caution, Undefined	Yellow
Status of normal, safe situation	Green

3.4 Requirements for preservation of night vision (UIDs and VDUs for installation on the navigating bridge)

3.4.1 Warning and alarm indicators shall show no light in normal condition.

3.4.2 All UIDs and VDUs shall be fitted with internal or permanent external light source to ensure that all necessary information is visible at all times.

3.4.3 Means shall be provided to avoid light and colour changes during start-up and mode changes, which may affect night vision.

4 Screen Based Systems

4.1 General

4.1.1 The status of the information displayed shall be clearly indicated.

This applies to e.g. indications not being updated or indication of inhibited alarm.

4.1.2 Alarm required in the rules shall, when initiated, be given priority over any other information presented on the VDU. The entire list of alarm messages shall be easily available.

4.1.3 Alarms shall be time tagged.

4.1.4 Time tagging for all alarms shall be consistent throughout the system. The different nodes in the system shall be synchronized with sufficient accuracy to ensure consistent time tagging for all alarms throughout the system.

The accuracy of the synchronization shall as a minimum correspond to the time constants in the process so that the true sequence of events may be traced in the alarm list.

4.1.5 For a main alarm system at least two independent VDUs shall be provided for alarm presentation, alternatively one VDU and one independent printer.

The two independent VDUs or VDU and printer shall not be driven from the same interface controller.

4.1.6 UIDs shall be designed and arranged to avoid inadvertent operation.

The purpose shall prevent unintentional activation / de-activation of systems, e.g. by means of a lid over a stop button or two-step operation of critical screen-based functions.

4.1.7 For essential and important systems, dedicated input devices shall be used.

The input device is normally a dedicated function keyboard, but alternative arrangements like e.g. touch-screens or dedicated software-based dialogue boxes or switches may be accepted on special considerations.

4.1.8 Symbols and their associated information in a mimic diagram shall have a logical relationship.

4.1.9 Means shall be provided to ensure that only correct use of numbers and letters and only values within reasonable limits will be accepted when data is entered manually into the system.

If the user provides the system with insufficient input, the system shall request the continuation of the dialogue by means of clarifying questions. Under no circumstances is the system to end the dialogue incomplete without user request.

4.2 Illumination

4.2.1 Means shall be provided for adjustment of illumination of all VDUs and UIDs to a level suitable for all applicable light conditions. However, to make adjustments down to a level making information belonging to essential and important functions unreadable is not permissible and shall be prevented.

Adjustments may be arranged by use of different sets of colours suited for the applicable light conditions.

4.3 Colour screens

4.3.1 For cathode ray tubes (CRTs), colours used for essential information shall not depend on a single source of light.

4.4 Computer dialogue

4.4.1 Frequently used operations shall be available in the upper menu level, on dedicated software or hardware buttons.

4.4.2 All menus and displays shall be self-explanatory or provided with appropriate help-functions.

4.4.3 When in dialogue mode, update of essential information shall not be blocked.

4.4.4 Relevant fields for entry of data shall occur with current or a default value. A valid data range shall be defined for each field.

4.4.5 The systems shall indicate the acceptance of a control action to the user without undue delay.

4.4.6 Confirmation of a command shall be used when the action requested has a critical consequence.

4.4.7 It shall be possible for the user to recognize whether the system is busy executing an operation, or waiting for additional user action. When the system is busy, buffering of more than one user input is not allowed.

Manually initiated time-consuming operations shall be possible to cancel.

4.5 Application screen views

4.5.1 For integrated systems, all windows to be called to the VDU shall have a similar representation of all components (menus, buttons, symbols, colours, etc.).

Chapter 4 Fire Protection, Detection And Extinction

Section 1 General

1 Premise

1.1 Contents

1.1.1 This section includes:

a) requirements of Chapter II-2 of SOLAS 1974 as amended and some IMO Assembly Resolutions, specified in the text; in reproducing the above text in this section applicable for the purpose of classification, the word "Administration", wherever mentioned, has been replaced by the word "Society"

2 Application

2.1 General

2.1.1 This Chapter applies to passenger ships and cargo ships (including tankers) of 500 gross tonnage and upwards, engaged in international voyages. Ships other than those specified above are to comply with the specific Rules of the Society.

2.2 National regulations

2.2.1 When the Administration of the State whose flag the ship is entitled to fly has issued specific rules covering fire protection, the Society may accept such rules for classification purposes in lieu of those given in this section.

In such cases a special notation regarding the above is entered on the Certificate of Class of the ship concerned.

This may apply to cargo ships of less than 500 gross tonnage or to ships not engaged in international voyages.

2.3 Applicable requirements depending on ship type

2.3.1 Unless expressly provided otherwise:

a) requirements not referring to a specific ship type are applied to ships of all types

b) requirements referring to “passenger ships” are applied to passenger ships as defined 3.31

c) requirements referring to “cargo ships” are applied to cargo ships as defined in 3.6 and tankers as defined in 3.40.

2.4 Documentation to be submitted

2.4.1 The interested party is to submit to the Society the documents listed in Table 2.1.

2.5 Type approved products

2.5.1 The following materials, equipment, systems or products in general used for fire protection are to be type approved by the Society, except for special cases for which the acceptance may be given for individual ships on the basis of suitable documentation or ad hoc tests:

a) Fire-resisting and fire-retarding divisions (bulkheads or decks) and associated doors

b) Upholstered furniture, excluding the frame (for spaces in 3.33)

c) Materials for pipes penetrating A or B class divisions (where they are not of steel or other equivalent material)

d) Materials for oil or fuel oil pipes (where they are not of steel or copper and its alloys)

e) Bulkhead or deck penetrations for electrical cables passing through A or B class divisions

f) Materials with low flame spread characteristic including paints, varnishes and similar, when they are required to have such characteristic

g) Non-combustible materials

h) Textile and non-textile materials suspended vertically, for example curtains (for spaces in 3.33)

i) Non-readily igniting materials for primary deck coverings

j) Fixed foam fire-extinguishing systems and associated foam-forming liquids

k) Fixed powder fire-extinguishing systems, including the powder

l) Flexible pipes and expansion bellows of non-conventional material for any type of fluid

m) Sprinkler heads for automatic sprinkler systems

n) Nozzles for fixed pressure water-spraying fire-extinguishing systems for machinery spaces, boiler rooms and spaces intended for the carriage of vehicles

o) Sensing heads for automatic fire alarm and fire detection systems

p) Fixed fire detection and fire alarm systems

q) Explosive mixture detecting systems

r) Portable explosive mixture detecting apparatus

s) Fixed instruments for measuring the oxygen content for inert gas systems serving cargo tanks

t) Portable instruments for measuring the oxygen content for inert gas systems serving cargo tanks

u) Fire dampers

v) Bedding components (for spaces defined in 3.33)

w) Equivalent water-mist fire-extinguishing systems

x) Equivalent fixed gas fire-extinguishing systems

y) Fixed local application fire-extinguishing systems

z) Equivalent water-mist automatic sprinkler systems.

As regards the granting of type approval, the corresponding requirements apply.

The Society may request type approval for other materials, equipment, systems or products required by the applicable provisions for ships or installations of special types.

Table 2.1: Documentation to be submitted

No	I/A (1)	Document (2)
1	A	Structural fire protection, showing the method of construction, purpose and category of the various spaces of the ships, the fire rating of bulkheads and decks, means of closings of openings in A and B class divisions, draught stops
2	A	Natural and mechanical ventilation systems showing the penetrations on A class divisions, location of dampers, means of closing, arrangements of air conditioning rooms
3	A	Means of escape and, where required, the relevant dimensioning. Escape route signage
4	A	Automatic fire detection systems and manually operated call points
5	A	Fire pumps and fire main including pumps head and capacity, hydrant and hose locations
6	A	Arrangement of fixed fire-extinguishing systems (2)
7	A	Arrangement of sprinkler or sprinkler equivalent systems including the capacity and head of the pumps (2)
8	A	Fire control plan
9	A	Fixed fire-extinguishing system in scavenge spaces of two-stroke crosshead type engines
10	A	Electrical diagram of the fixed gas fire-extinguishing systems
11	A	Electrical diagram of the sprinkler systems
12	A	Electrical diagram of power control and position indication circuits for fire doors
13	I	General arrangement plan

(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 fireextinguishing systems
- capacity, in volume and/or in mass, of vessels or bottles containing the extinguishing media or propelling gases, for gas, automatic sprinkler, foam and powder fire-extinguishing systems
- type, number and location of nozzles of extinguishing media for gas, automatic sprinkler, pressure water-spraying, foam and powder fire-extinguishing systems.

All or part of the information may be provided, instead of on the above plans, in suitable operation manuals or in specifications of the systems.

3 Definitions

3.1 Accommodation spaces

3.1.1 Accommodation spaces are those spaces used for public spaces, corridors, stairs, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces.

3.1.2 Pantries (including isolated pantries) containing no cooking appliances may contain:

- coffee automats, toasters, dishwashers, microwave ovens, water boilers and similar appliances, each with a maximum power of 5 kW
- electrically heated cooking plates and hot plates for keeping food warm, each with a maximum power of 2kW and a surface temperature not greater than 150°C.

A dining room containing such appliances is not regarded as a pantry.

3.2 A class divisions

3.2.1 "A" class divisions are those divisions formed by bulkheads and decks which comply with the following criteria:

a) they are constructed of steel or other equivalent material

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 minutes
- class "A-30" 30 minutes
- class "A-15" 15 minutes
- class "A-0" 0 minutes

d) they are so constructed as to be capable of preventing the passage of smoke and flame to the end of the onehour standard fire test; and

e) the Society required a test of a prototype bulkhead or deck in accordance with the Fire Test Procedures Code (see 3.19) to ensure that it meets the above requirements for integrity and temperature rise.

3.2.2 The products indicated in Table 3.1 may be installed without testing or approval.

3.3 Atriums

3.3.1 Atriums are public spaces within a single main vertical zone spanning three or more open decks.

3.4 B class divisions

3.4.1 "B" class divisions are those 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 used in the construction and erection of "B" class divisions are non-combustible, with the exception that combustible veneers may be permitted provided they meet other appropriate requirements of this section

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 minutes
- class "B-0" 0 minutes

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; and d) the Society required a test of a prototype division in accordance with the Fire Test Procedures Code (see 3.19) to ensure that it meets the above requirements for integrity and temperature rise.

3.4.2 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.

3.5 Bulkhead decks

3.5.1 The bulkhead deck is the uppermost deck up to which the transverse watertight bulkheads are carried.

3.6 Cargo ship

3.6.1 Cargo ship is any ship which is not a passenger ship.

3.7 Cargo spaces

3.7.1 Cargo spaces are spaces used for cargo, cargo oil tanks, tanks for other liquid cargo and trunks to such spaces.

3.8 Central control station

3.8.1 The central control station is a control station in which the following control and indicator functions are centralized:

a) fixed fire detection and fire alarm systems

b) automatic sprinkler, fire detection and fire alarm systems

c) fire door indicator panels

d) fire door closures

e) watertight door indicator panels

f) watertight door closures

g) ventilation fans

h) general/fire alarms

i) communication systems including telephones; and

Note: The communication systems referred to are only those required by this Section.

j) microphones to public address systems.

Table 3.1: Products installed without testing or approval

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

3.9 C class divisions

3.9.1 "C" class divisions are divisions constructed of approved non-combustible materials. They need meet neither requirements relative to the passage of smoke and flame nor limitations relative to the temperature rise. Combustible veneers are permitted provided they meet the requirements of this Section.

3.10 Chemical tankers

3.10.1 A chemical tanker is a cargo ship constructed or adapted and used for the carriage in bulk of any liquid product of a flammable nature.

3.11 Closed ro-ro spaces

3.11.1 Closed ro-ro spaces are ro-ro spaces which are neither open ro-ro spaces nor weather decks.

3.12 Closed vehicle spaces

3.12.1 Closed vehicle spaces are vehicle spaces which are neither open vehicle spaces nor weather decks.

3.13 Combination carriers

3.13.1 A combination carrier is a cargo ship designed to carry both oil and solid cargoes in bulk.

3.14 Continuous B class ceilings or linings

3.14.1 Continuous "B" class ceilings or linings are those "B" class ceilings or linings which terminate at an "A" or "B" class division.

3.15 Continuously manned central control stations

3.15.1 A continuously manned central control station is a central control station which is continuously manned by a responsible member of the crew.

3.16 Control stations

3.16.1 Control stations are those spaces in which the ship's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralized.

3.17 Dangerous goods

3.17.1 Dangerous goods are those goods belonging to the following classes:

- class 1 - Explosives
- class 2 - Gases: compressed, liquefied or dissolved under pressure
- class 3 - Flammable liquids
- class 4.1 - Flammable solids
- class 4.2 - Substances liable to spontaneous combustion
- class 4.3 - Substances which, in contact with water, emit flammable gases
- class 5.1 - Oxidizing substances
- class 5.2 - Organic peroxides
- class 6.1 - Poisonous (toxic) substances
- class 6.2 - Infectious substances
- class 7 - Radioactive materials
- class 8 - Corrosives
- class 9 - Miscellaneous dangerous substances (that is any other substance which experience has shown, or may show, to be of such a dangerous character that the provisions of Part A, Chapter VII of SOLAS Convention are to be applied).

3.18 Deadweight

3.18.1 The deadweight is the difference in tonnes between the displacement of a ship in water of a specific gravity of 1,025 at the load waterline corresponding to the assigned summer freeboard and the lightweight of the ship.

3.19 Fire Test Procedures Code

3.19.1 Fire Test Procedures Code means the “International Code for Application of Fire Test Procedures”, as adopted by the Maritime Safety Committee of the IMO by Resolution MSC.61 (67), as may be amended by the IMO.

3.20 Gas carriers

3.20.1 A gas carrier is a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas or other products of a flammable nature.

3.21 Lightweight

3.21.1 The lightweight is the displacement of a ship in tonnes without cargo, fuel, lubricating oil, ballast water, fresh water and feedwater in tanks, consumable stores, and passengers and crew and their effects.

3.22 Low flame-spread

3.22.1 A low flame-spread means that the surface thus described will adequately restrict the spread of flame, this being determined in accordance with the Fire Test Procedures Code.

3.22.2 Non-combustible materials are considered as low flame spread. However, due consideration will be given by the Society to the method of application and fixing.

3.23 Machinery spaces

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

3.24 Machinery spaces of category A

3.24.1 Machinery spaces of category A are those spaces and trunks to such spaces which contain either:

a) internal combustion machinery used for main propulsion

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 oil fuel unit, or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

3.25 Main vertical zones

3.25.1 Main vertical zones are those sections into which the hull, superstructure and deckhouses are divided by “A“ class divisions, the mean length and width of which on any deck does not in general exceed 40 m.

3.26 Non-combustible material

3.26.1 Non-combustible material is 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. Any other material is a combustible material.

3.26.2 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.

3.27 Oil fuel unit

3.27.1 The oil fuel unit is the equipment used for the preparation of oil fuel 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 MPa.

3.27.2 "Fuel oil unit" includes any equipment used for the preparation and delivery of fuel oil, whether or not heated, to boilers (including inert gas generators) and engines (including gas turbines) at a pressure of more than 0,18 MPa.

3.28 Non-sparking fan

3.28.1 A fan is considered as non-sparking if in either normal or abnormal conditions it is unlikely to produce sparks.

For this purpose, the following criteria are to be met:

a) Design criteria

1) 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 and in any case not less than 2 mm, but need not exceed 13 mm.

2) Protective screens with square mesh of not more than 13 mm are to be fitted to the inlet and outlet of ventilation ducts to prevent objects entering the fan housing.

b) Materials

1) The impeller and the housing in way of the impeller are to be made of spark-proof materials which are recognized as such by means of an appropriate test to the satisfaction of the Society.

2) Electrostatic charges, both in the rotating body and the casing, are to be prevented by the use of antistatic materials. Furthermore, the installation on board of ventilation units is to be such as to ensure their safe bonding to the hull.

3) Tests may not be required for fans having the following material combinations:

- impellers and/or housings of non-metallic material, due regard being paid to the elimination of static electricity
- impellers and housings of non-ferrous materials
- impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous material is fitted in way of the impeller
- any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm design tip clearance.

4) The following impeller and housing combinations are considered as sparking and therefore are not permitted:

- impellers of an aluminium alloy or a magnesium alloy and a ferrous housing, regardless of tip clearance
- housings made of an aluminium alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance
- any combination of ferrous impeller and housing with less than 13 mm design tip clearance.

5) Complete fans are to be type-tested in accordance with either the Society's requirements or national or international standards accepted by the Society.

3.29 Open ro-ro spaces

3.29.1 Open ro-ro spaces are those ro-ro spaces which are either open at both ends or have an opening at one end, and are provided with adequate natural ventilation effective over their entire length through permanent openings distributed in the side plating or deckhead or from above, having a total area of at least 10% of the total area of the space sides.

3.30 Open vehicle spaces

3.30.1 Open vehicle spaces are those 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 their entire length through permanent openings distributed in the side plating or deckhead or from above, having a total area of at least 10% of the total area of the space sides.

3.31 Passenger ship

3.31.1 Passenger ship is a ship which carries more than twelve passengers

3.32 Public spaces

3.32.1 Public spaces are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

3.33 Rooms containing furniture and furnishings of restricted fire risk

3.33.1 Rooms containing furniture and furnishings of restricted fire risk, for the purpose of Sec 5, 1.3.3, are those rooms containing furniture and furnishings of restricted fire risk (whether cabins, public spaces, offices or other types of accommodation) in which:

a) case furniture such as desks, wardrobes, dressing tables, bureaux, or dressers are constructed entirely of approved non-combustible materials, except that a combustible veneer not exceeding 2 mm may be used on the working surface of such articles

b) free-standing furniture such as chairs, sofas, or tables are constructed with frames of non-combustible materials

c) draperies, curtains and other suspended textile materials have qualities of resistance to the propagation of flame not inferior to those of wool having a mass of 0.8 kg/m^2, this being determined in accordance with the Fire Test Procedures Code (see 3.19)

d) floor coverings have low flame-spread characteristics;

e) exposed surfaces of bulkheads, linings and ceilings have low flame-spread characteristics

f) upholstered furniture has qualities of resistance to the ignition and propagation of flame, this being determined in accordance with the Fire Test Procedures Code (see 3.19), and

g) bedding components have qualities of resistance to the ignition and propagation of flame, this being determined in accordance with the Fire Test Procedures Code (see 3.19).

3.34 Ro-ro spaces

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

3.35 Ro-ro passenger ship

3.35.1 Ro-ro passenger ship means a passenger ship with ro-ro spaces or special category spaces as defined in 3.38.

3.36 Steel or other equivalent material

3.36.1 Steel or other equivalent material means any noncombustible material which, by itself or due to insulation provided, has 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).

3.37 Service spaces

3.37.1 Service spaces are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store-rooms, workshops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces.

3.37.2

a) Main pantries and pantries containing cooking appliances may contain:

1) coffee automats, toasters, dishwashers, microwave ovens, water boilers and similar appliances, each with a power of more than 5 kW

2) electrically heated cooking plates and hot plates for keeping food warm, each with a maximum power of 5 kW.

b) Spaces containing any electrically heated cooking plate or hot plate for keeping food warm with a power of more than 5 kW are to be regarded, for the purpose of Sec 5, as galleys.

3.38 Special category spaces

3.38.1 Special category spaces are those enclosed vehicle spaces above and below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access. Special category spaces may be accommodated on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m.

3.39 Standard fire test

3.39.1 A standard fire test is a test in which specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time-temperature curve in accordance with the test method specified in the Fire Test Procedures Code (see 3.19).

3.40 Tanker

3.40.1 Tanker is a cargo ship constructed or adapted for the carriage in bulk of liquid cargoes of an inflammable nature.

Note 1: For the purpose of this Section, the term tanker includes the following service notations:

- Chemical tanker
- Combination carrier/OBO
- Combination carrier/OOC

- Flammable liquid substances tanker
- Liquefied gas carrier
- Oil recovery ship
- Oil tanker.

3.41 Vehicle spaces

3.41.1 Vehicle spaces are cargo spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion, including special category spaces.

3.42 Weather decks

3.42.1 Weather deck is a deck which is completely exposed to the weather from above and from at least two sides.

3.43 Cabin balconies

3.43.1 Cabin balcony is an open deck which is provided for the exclusive use of the occupants of a single cabin and has direct access from such a cabin.

Section 2 Prevention of Fire

1 Probability of ignition

1.1 Arrangements for fuel oil, lubrication oil and other flammable oils

1.1.1 Limitation in the use of oils as fuel, See. Ch. 1, Sec. 1

1.1.2 Arrangements for fuel oil See Ch. 1, Sec. 11.

1.1.3 Arrangements for lubricating oil See Ch. 1, Sec. 11.

1.1.4 Arrangements for other flammable oils, See Ch. 1, Sec. 11.

1.2 Arrangements for gaseous fuel for domestic purposes

1.2.1 Where gaseous fuel is used for domestic purposes the arrangements for the storage, distribution and utilization of the fuel shall be such that, having regard to the hazards of fire and explosion which the use of such fuel may entail, the safety of the ship and the persons on board is preserved. See also Ch. 1, Sec. 11.

1.2.2 Gaseous fuel systems may only be considered for cargo ships.

1.2.3 Storage of the gas bottles is to be located on the open deck or in a well ventilated space which opens only to the open deck.

1.3 Miscellaneous items of ignition sources and ignitability

1.3.1 Electric radiators

Electric radiators, if used, shall be fixed in position and so constructed as to reduce fire risks to a minimum. No such radiators shall be fitted with an element so exposed that clothing, curtains, or other similar materials can be scorched or set on fire by heat from the element.

1.3.2 Cellulose-nitrate based films

Cellulose-nitrate based films shall not be used for cinematograph installations.

1.3.3 Waste receptacles

In principle, all waste receptacles shall be constructed of non-combustible materials with no openings in the sides or bottom.

1.3.4 Insulation surfaces against oil penetration

In spaces where penetration of oil products is possible, the surface of insulation shall be impervious to oil or oil vapours.

1.3.5 Primary deck coverings

Primary deck coverings, if applied within accommodation and service spaces and control stations or if applied on cabin balconies of passenger ships, shall be of approved material which will not readily ignite, this being determined in accordance with the Fire Test Procedures Code (see Sec 1, 3.19).

2 Fire growth potential

2.1 Control of air supply and flammable liquid to the space

2.1.1 Closing appliances and stopping devices of ventilation

a) The main inlets and outlets of all ventilation systems shall be capable of being closed from outside the spaces being ventilated. The means of closing shall be easily accessible as well as prominently and permanently marked and shall indicate whether the shut-off is open or closed.

Ventilation inlets and oulets located at outside boundaries are to be fitted with closing appliances as required above and need not comply with Sec 5, 6.4.1.

b) Power ventilation of accommodation spaces, service spaces, cargo spaces, control stations and machinery spaces shall be capable of being stopped from an easily accessible position outside the space being served. This position shall not be readily cut off in the event of a fire in the spaces served.

c) In passenger ships carrying more than 36 passengers, all power ventilation, except machinery space and cargo space ventilation and any alternative system which may be required under Sec 4, 2.1.1, shall be fitted with controls so grouped that all fans may be stopped from either of two separate positions which shall be situated as far apart as practicable. Fans serving power ventilation systems to cargo spaces shall be capable of being stopped from a safe position outside such spaces.

2.1.2 Means of control in machinery spaces

a) Means of control shall be provided for opening and closure of skylights, closure of openings in funnels which normally allow exhaust ventilation and closure of ventilator dampers.

b) Means of control shall be provided for stopping ventilating fans. Controls provided for the power ventilation serving machinery spaces shall be grouped so as to be operable from two positions, one of which shall be outside such spaces. The means provided for stopping the power ventilation of the machinery spaces shall be entirely separate from the means provided for stopping ventilation of other spaces.

c) Means of control shall be provided for stopping forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pumps, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers).

However, items d) and e) hereafter need not apply to oily water separators.

d) The controls required in a) to c) above shall be located outside the space concerned so they will not be cut off in the event of fire in the space they serve.

In machinery spaces of category A, controls to close off ventilation ducts and pipes are to be installed with due regard to the hot gases produced by a fire in the space concerned.

e) In passenger ships, the controls required in items a) to d) above and in Sec 4, 2.2.2 and Sec 5, 4.2.2 and the controls for any required fire-extinguishing system shall be situated at one control position or grouped in as few positions as possible to the satisfaction of the Society. Such positions shall have a safe access from the open deck.

2.2 Fire protection materials

2.2.1 Use of non-combustible materials

a) Insulating materials

Insulating materials shall be non-combustible, except in cargo spaces, mail rooms, baggage rooms and refrigerated compartments of service spaces. Vapour barriers and adhesives used in conjunction with insulation, as well as insulation of pipe fittings for cold service systems, need not be of non-combustible materials, but they shall be kept to the minimum quantity practicable and their exposed surfaces shall have low flame-spread characteristics.

Cold service means refrigeration systems and chilled water piping for air conditioning systems.

b) Ceilings and linings

1) Item 2 below applies to passenger ships and item 3 applies to cargo ships.
2) Except in cargo spaces, all linings, grounds, draught stops and ceilings shall be of non-combustible materials except in mail rooms, baggage rooms, saunas or refrigerated compartments of service spaces.
3) All linings, ceilings, draught stops and their associated grounds shall be of non-combustible materials:

- in accommodation and service spaces and control stations for ships where method IC is specified as referred to in Sec 5, 1.4.1; and
- in corridors and stairway enclosures serving accommodation and service spaces and control stations for ships where methods IIC or IIIC are specified as referred to in Sec 5, 1.4.1.

c) Partial bulkheads and decks on passenger ships

1) Partial bulkheads or decks used to subdivide a space for utility or artistic treatment shall be of non-combustible materials.
2) Linings, ceilings and partial bulkheads or decks used to screen or to separate adjacent cabin balconies shall be of non-combustible materials.

2.2.2 Use of combustible materials

a) General

1) Item 2) below applies to passenger ships and item 3) applies to cargo ships.
2) “A”, “B” or “C” class divisions in accommodation and service spaces and cabin balconies which are faced with combustible materials, facings, mouldings, decorations and veneers shall comply with the provisions of b) to d) below and Article 3. However, the provisions of c) need not apply to cabin balconies.
3) Non-combustible bulkheads, ceilings and linings fitted in accommodation and service spaces may be faced with combustible materials, facings, mouldings, decorations and veneers provided such spaces are bounded by non-

combustible bulkheads, ceilings and linings in accordance with the provisions of b) to d) below and article 3.

b) Maximum calorific value of combustible materials Combustible materials used on the surfaces and linings specified in item a) shall have a calorific value (see 2.2.2, Note 1) not exceeding 45 MJ/m2 of the area for the thickness used. The requirements of this paragraph are not applicable to the surfaces of furniture fixed to linings or bulkheads.

c) Total volume of combustible materials Where combustible materials are used in accordance with the previous item a), they shall comply with the following requirement:

1) The total volume of combustible facings, mouldings, decorations and veneers in accommodation and service spaces shall not exceed a volume equivalent to 2,5 mm veneer on the combined area of the walls and ceiling linings. Furniture fixed to linings, bulkheads or decks need not be included in the calculation of the total volume of combustible materials.

d) Low flame-spread characteristics of exposed surface in passenger ships

The following surfaces shall have low flame-spread characteristics in accordance with the the Fire Test Procedures Code:

1) exposed surfaces in corridors and stairway enclosures and of bulkhead and ceiling linings in accommodation and service spaces (except saunas) and control station

2) surfaces and grounds in concealed or inaccessible spaces in accommodation and services spaces and control stations

3) exposed surfaces of cabin balconies, except for natural wood deckin systems.

e) Low flame spread characteristics of exposed surface in cargo ships

The following surfaces shall have low flame spread characteristics in accordance with the Fire Test Procedures Code:

1) exposed surfaces in corridors and stairway enclosures and of ceilings in accommodation and service spaces (except saunas) and control stations; and

2) surfaces and grounds in concealed or inaccessible spaces in accommodation and service spaces and control stations.

Note 1: The gross calorific value measured in accordance with ISO Standard 1716 “Building Materials - Determination of Calorific Potential” should be quoted.

2.2.3 Furniture in stairway enclosures

a) 2.2.3 applies to passenger ships.

b) Furniture in stairway enclosures shall be limited to seating. It shall be fixed, limited to six seats on each deck in each stairway enclosure, be of restricted fire risk determined in accordance with the Fire Test Procedures Code, and shall not restrict the passenger escape route.

The Society may permit additional seating in the main reception area within a stairway enclosure if it is fixed, non-combustible and does not restrict the passenger escape route. Furniture shall not be permitted in passenger and crew corridors forming escape routes in cabin areas. In addition to the above, lockers of non-combustible material, providing storage for non-hazardous safety equipment required by these regulations, may be permitted.

Drinking water dispensers and ice cube machines may be permitted in corridors provided they are fixed and do not restrict the width of the escape routes. This applies as well to decorative flower or plant arrangements, statues or other objects of art such as paintings and tapestries in corridors and stairways

2.2.4 Furniture and furnishings on cabin balconies of passenger ships

On passenger ships, furniture and furnishings shall comply with Sec 1, 3.33.1, items a), b), c), f) and g) unless such balconies are protected by a fixed pressure water spraying and fixed fire detection and alarm systems complying with Sec 3, 9.1 and Sec 6, 5.1.3.

3 Smoke generation potential and toxicity

3.1 Paints, varnishes and other finishes

3.1.1 Paints, varnishes and other finishes used on exposed interior surfaces shall not be capable of producing excessive quantities of smoke and toxic products, this being determined in accordance with the Fire Test Procedures Code.

3.1.2 This requirement only applies to accommodation spaces, service spaces and control stations as well as stairway enclosures.

3.1.3 On passenger ships, paints, varnishes and other finishes used on exposed surfaces of cabin balconies shall not be capable of producing excessive quantities of smoke and toxic products, this being determined in accordance with the Fire Test Procedures Code.

3.2 Primary deck coverings

3.2.1 Primary deck coverings, if applied within accommodation and service spaces and control stations, shall be of approved material which will not give rise to smoke or toxic or explosive hazards at elevated temperatures, this being determined in accordance to the Fire Test Procedures Code.

3.2.2 On passenger ships, primary deck coverings on cabin balconies shall be of approved material which will not give rise to smoke or toxic or explosive hazards at elevated temperatures, this being determined in accordance to the Fire Test Procedures Code.

Section 3 Suppression of Fire: Detection and Alarm

1 General

1.1 Minimum number of detectors

1.1.1 Where a fixed fire detection and fire alarm system is required for the protection of spaces other than those specified in 4.2.1, at least one detector complying with the requirements given in Sec 13 shall be installed in each such space.

2 Initial and periodical tests

2.1 General

2.1.1 The function of fixed fire detection and fire alarm systems required by the relevant subsections of this Section shall be tested under varying conditions of ventilation after installation.

2.1.2 The function of fixed fire detection and fire alarm systems shall be periodically tested to the satisfaction of the Society by means of equipment producing hot air at the appropriate temperature, or smoke or aerosol particles having the appropriate range of density or particle size, or other phenomena associated with incipient fires to which the detector is designed to respond.

3 Protection of machinery spaces

3.1 Installation

3.1.1 A fixed fire detection and fire alarm system complying with the relevant provisions given in Sec 13 shall be installed in:

a) periodically unattended machinery spaces, and

b) machinery spaces where:

1) the installation of automatic and remote control systems and equipment has been approved in lieu of continuous manning of the space, and

2) the main propulsion and associated machinery, including the main sources of electrical power, are provided with various degrees of automatic or remote control and are under continuous manned supervision from a control room.

The requirements of this item apply to machinery spaces of category A.

For fire detecting system for unattended machinery spaces, see also Chapter 3.

3.2 Design

3.2.1 The fixed fire detection and fire alarm system required in 3.1.1 a) shall be so designed and the detectors so positioned as to detect rapidly the onset of fire in any part of those spaces and under any normal conditions of operation of the machinery and variations of ventilation as required by the possible range of ambient temperatures. Except in spaces of restricted height and where their use is specially appropriate, detection systems using only thermal detectors shall not be permitted.

The detection system shall initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire, in sufficient places to ensure that the alarms are heard and observed on the navigation bridge and by a responsible engineer officer. When the navigation bridge is unmanned, the alarm shall sound in a place where a responsible member of the crew is on duty.

4 Protection of accommodation and service spaces and control stations

4.1 Application

4.1.1 The provisions of 4.2 apply to ships of all types, those of 4.3 to 4.5 apply to passenger ships and those of 4.6 apply to cargo ships.

4.2 Smoke detectors in accommodation spaces

4.2.1 Smoke detectors shall be installed in all stairways, corridors and escape routes within accommodation spaces.

Consideration shall be given to the installation of special purpose smoke detectors within ventilation ducting.

4.3 Requirements for passenger ships carrying more than 36 passengers

4.3.1 A fixed fire detection and fire alarm system shall be so installed and arranged as to provide smoke detection in service spaces, control stations and accommodation spaces, including corridors, stairways and escape routes within accommodation spaces. Smoke detectors need not be fitted in private bathrooms and galleys. Spaces having little or no fire risk such as voids, public toilets, carbon dioxide rooms and similar spaces need not be fitted with a fixed fire detection and alarm system.

Heat detectors in lieu of smoke detectors may be installed in galleys. CO2 rooms need not be protected by a fire detection system or a sprinkler system.

4.4 Requirements for passenger ships carrying not more than 36 passengers

4.4.1 There shall be installed throughout each separate zone, whether vertical or horizontal, in all accommodation and service spaces and, where it is considered necessary by the Society, in control stations, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc., either:

a) a fixed fire detection and fire alarm system so installed and arranged as to detect the presence of fire in such spaces and providing smoke detection in corridors, stairways and escape routes within accommodation spaces; or

b) an automatic sprinkler, fire detection and fire alarm system of an approved type complying with the relevant requirements of Sec 13 and so installed and arranged as to protect such spaces and, in addition, a fixed fire detection and fire alarm system so installed and arranged as to provide smoke detection in corridors, stairways and escape routes within accommodation spaces.

CO_2 rooms need not be protected by a fire detection system or a sprinkler system.

4.5 Protection of atriums

4.5.1 The entire main vertical zone containing the atrium shall be protected throughout with a smoke detection system.

4.6 Cargo ships

4.6.1 Accommodation and service spaces and control stations of cargo ships shall be protected by a fixed fire detection and fire alarm system and/or an automatic sprinkler, fire detection and fire alarm system as follows, depending on a protection method adopted in accordance with Sec 5, 1.4.1.

a) Method IC

A fixed fire detection and fire alarm system shall be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces.

b) Method IIC

An automatic sprinkler, fire detection and fire alarm system of an approved type complying with the relevant requirements of Sec 13 shall be so installed and arranged as to protect accommodation spaces, galleys and other service spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc.

In addition, a fixed fire detection and fire alarm system shall be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces.

c) Method IIIC

A fixed fire detection and fire alarm system shall be so installed and arranged as to detect the presence of fire in all accommodation spaces and service spaces, providing smoke detection in corridors, stairways and escape routes within accommodation spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc. In addition, a fixed fire detection and fire alarm system shall be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces.

CO2 rooms need not be protected by a fire detection system or a sprinkler system.

5 Protection of cargo spaces

5.1 Application and general requirements

5.1.1 The present Article applies to passenger ships.

5.1.2 A fixed fire detection and fire alarm system complying with the requirements of Sec 13 or a sample extraction smoke detection system complying with the requirements of Sec 13 shall be provided in any cargo space which, in the opinion of the Society, is not accessible, except where it is shown to the satisfaction of the Society that the ship is engaged on voyages of such short duration that it would be unreasonable to apply this requirement.

6 Manually operated call points

6.1 General requirements

6.1.1 Manually operated call points complying with the requirements of Sec 13 shall be installed throughout the accommodation spaces, service spaces and control stations.

One manually operated call point shall be located at each exit. Manually operated call points shall be readily accessible in the corridors of each deck such that no part of the corridor is more than 20 m from a manually operated call point.

7 Inspection hatches

7.1 Application

7.1.1 The present Article applies to passenger ships.

7.2 Inspection hatches

7.2.1 The construction of ceilings and bulkheads shall be such that it will be possible, without impairing the efficiency of the fire protection, for the fire patrols to detect any smoke originating in concealed and inaccessible places, except where in the opinion of the Society there is no risk of fire originating in such places.

8 Fire alarm signaling systems

8.1 Application

8.1.1 The present Article applies to passenger ships.

8.2 Control panel

8.2.1 The control panel of fixed fire detection and fire alarm systems shall be designed on the fail-safe principle, e.g. an open detector circuit shall cause an alarm condition.

8.3 Passenger ships carrying more than 36 passengers

8.3.1 Passenger ships carrying more than 36 passengers shall have the fire detection alarms for the systems required by 4.3, centralized in a continuously manned central control station. In addition, controls for remote closing of the fire doors and shutting down the ventilation fans shall be centralized in the same location. The ventilation fans shall be capable of reactivation by the crew at the continuously manned control station. The control panels in the central control station shall be capable of indicating open or closed positions of fire doors and closed or off status of the detectors, alarms and fans. The control panel shall be continuously powered and shall have an automatic change-over to standby power supply in case of loss of normal power supply.

The control panel shall be powered from the main source of electrical power and the emergency source of electrical power unless other arrangements are permitted by the Rules, as applicable.

8.4 Special alarm

8.4.1 A special alarm, operated from the navigation bridge or fire control station, shall be fitted to summon the crew. This alarm may be part of the ship's general alarm system and shall be capable of being sounded independently of the alarm to the passenger spaces.

9 Protection of cabin balconies on passenger ships

9.1

9.1.1 A fixed fire detection and alarm system complying with the provisions of the Fire Safety Systems Code shall be installed on cabin balconies to which Sec 2, 2.2.4 applies, when furniture and furnishings on such balconies are not defined in Sec 1, 3.33.1, items a), b), c), f) and g).

Section 4 Suppression of Fire: Control of Smoke Spread

1 General

1.1 Application

1.1.1 The provisions of 2.1 to 2.3 except 2.2.3 apply to ships of all types. Those of 2.2.3 and 2.4 apply to passenger ships.

2 Protection of control stations outside machinery spaces

2.1 General

2.1.1 Practicable measures shall be taken for control stations outside machinery spaces in order to ensure that ventilation, visibility and freedom from smoke are maintained so that, in the event of fire, the machinery and equipment contained therein may be supervised and continue to function effectively. Alternative and separate means of air supply shall be provided and air inlets of the two sources of supply shall be so disposed that the risk of both inlets drawing in smoke simultaneously is minimized. At the discretion of the Society, such requirements need not apply to control stations situated on, and opening onto, an open deck or where local closing arrangements would be equally effective.

2.1.2 Equally effective local closing arrangements means that in the case of ventilators these are to be fitted with fire dampers or smoke dampers which are to be easily closed within the control station in order to maintain the absence of smoke in the event of fire.

2.2 Release of smoke from machinery spaces

2.2.1 Suitable arrangements shall be made to permit the release of smoke, in the event of fire, from the space to be protected. The normal ventilation systems may be acceptable for this purpose.

2.2.2 Means of control shall be provided for permitting the release of smoke and such controls shall be located outside the space concerned so that they will not be cut off in the event of fire in the space they serve.

2.2.3 The controls required by 2.2.2 shall be situated at one control position or grouped in as few positions as possible to the satisfaction of the Society. Such positions shall have a safe access from the open deck.

2.3 Draught stops

2.3.1 Air spaces enclosed behind ceilings, panelling or linings shall be divided by close-fitting draught stops spaced not more than 14 m apart. In the vertical direction, such enclosed air spaces, including those behind linings of stairways, trunks, etc., shall be closed at each deck.

2.4 Smoke extraction systems in atriums

2.4.1 Atriums shall be equipped with a smoke extraction system. The smoke extraction system shall be activated by the required smoke detection system and be capable of manual control. The fans shall be sized such that the entire volume within the space can be exhausted in 10 min or less.

Section 5 Suppression of Fire: Containment of Fire

1 Thermal and structural boundaries

1.1 Application

1.1.1 The provisions of 1.2 apply to ships of all types, those of 1.3 apply to passenger ships, those of 1.4 apply to cargo ships and those of 1.5 apply to tankers.

1.2 Thermal and structural subdivision

1.2.1 Ships of all types shall be subdivided into spaces by thermal and structural divisions having regard to the fire risk of the space.

Table 1.1: Bulkheads not bounding either main vertical zones or horizontal zones in passenger ships carrying more than 36 passengers

SPACES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Control stations (1)	B-0 [a]	A-0	A-0	A-0	A-0	A-60	A-60	A-60	A-0	A-0	A-60	A-60	A-60	A-60
Stairways (2)		A-0 [a]	A-0	A-0	A-0	A-0	A-15	A-15	A-0 [c]	A-0	A-15	A-30	A-15	A-30
Corridors (3)			B-15	A-60	A-0	B-15	B-15	B-15	B-15	A-0	A-15	A-30	A-0	A-30
Evacuation stations and external escape routes (4)				-	A-0	A-60 [b][d]	A-60 [b][d]	A-60 [b][d]	A-60[d]	A-0	A-60[b]	A-60[b]	A-60[b]	A-60[b]
Open deck spaces (5)					-	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of minor fire risk (6)						B-0	B-0	B-0	C	A-0	A-0	A-30	A-0	A-30
Accommodation spaces of moderate fire risk (7)							B-0	B-0	C	A-0	A-15	A-60	A-15	A-60
Accommodation spaces of greater fire risk (8)								B-0	C	A-0	A-30	A-60	A-15	A-60
Sanitary and similar spaces (9)									C	A-0	A-0	A-0	A-0	A-0
Tanks, voids and auxiliary machinery spaces having little or no fire risk (10)										A-0 [a]	A-0	A-0	A-0	A-0
Auxiliary machinery spaces, cargo spaces, cargo and other oil tanks and other similar spaces of moderate fire risk (11)											A-0 [a]	A-0	A-0	A-15
Machinery spaces and main galleys (12)												A-0 [a]	A-0	A-60
store-rooms, workshops, pantries etc. (13)													A-0 [a]	A-0
Other spaces in which flammable liquids are stowed (14)														A-30

Note 1: (to be applied to Table 1.1 and Table 1.2, as appropriate)

[a] : Where adjacent spaces are in the same numerical category and letter “a” appears, a bulkhead or deck between such spaces need not be fitted if deemed unnecessary by the Society. For example, in category (12) a bulkhead need not be required between a galley and its annexed pantries provided the pantry bulkheads and decks maintain the integrity of the galley boundaries. A bulkhead is, however, required between a galley and machinery space even though both spaces are in category (12).

[b] : The ship's side, to the waterline in the lightest seagoing condition, superstructure and deckhouse sides situated below and adjacent to liferafts and evacuation slides may be reduced to A-30.

[c] : Where public toilets are installed completely within the stairway enclosure, the public toilet bulkhead within the stairway enclosure can be of B class integrity.

[d] : Where spaces of category (6), (7), (8) and (9) are located completely within the outer perimeter of the assembly station, the bulkheads of these spaces are allowed to be of B-0 class integrity. Control positions for audio, video and light installations may be considered as part of the assembly station.

1.3 Passenger ships

1.3.1 Main vertical zones and horizontal zones

a) In ships carrying more than 36 passengers, the hull, superstructure and deckhouses shall be subdivided into main vertical zones by A-60 class divisions. Steps and recesses shall be kept to a minimum, but where they are necessary they shall also be A-60 class divisions. Where a category (5), (9) or (10) space defined in item b) of 1.3.3 is on one side or where fuel oil tanks are on both sides of the division the standard may be reduced to A-0.

b) In ships carrying not more than 36 passengers, the hull, superstructure and deckhouses in way of accommodation and service spaces shall be subdivided into main vertical zones by A class divisions. These divisions shall have insulation values in accordance with Table 1.3 and Table 1.4.

c) As far as practicable, the bulkheads forming the boundaries of the main vertical zones above the bulkhead deck shall be in line with watertight subdivision bulkheads situated immediately below the bulkhead deck. The length and width of main vertical zones may be extended to a maximum of 48 m in order to bring the ends of main vertical zones to coincide with watertight subdivision bulkheads or in order to accommodate a large public space extending for the whole length of the main vertical zone provided that the total area of the main vertical zone is not greater than 1600 m2 on any deck. The length or width of a main vertical zone is the maximum distance between the furthermost points of the bulkheads bounding it.

If a stairway serves two main vertical zones, the maximum length of any one main vertical zone need not be measured from the far side of the stairway enclosure. In this case all boundaries of the stairway enclosure are to be insulated as main vertical zone bulkheads and access doors leading into the stairway are to be provided from the two outside zones. The number of main vertical zones of 48 m length is not limited as long as they comply with all the requirements.

d) Such bulkheads shall extend from deck to deck and to the shell or other boundaries.

e) On ships designed for special purposes, such as automobile or railroad car ferries, where the provision of main vertical zone bulkheads would defeat the purpose for which the ship is intended, equivalent means for controlling and limiting a fire shall be substituted and specifically approved by the Society.

However, in a ship with special category spaces, such spaces shall comply with the applicable provisions of Sec 12 and, where such compliance would be inconsistent with other requirements for passenger ships specified in this Section, the requirements of Sec 12 shall prevail.

Table 1.2: Decks not forming steps in main vertical zones nor bounding horizontal zones in passenger ships carrying more than 36 passengers

Space Below	Space Above													
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Control stations (1)	A-30	A-30	A-15	A-0	A-0	A-0	A-15	A-30	A-0	A-0	A-0	A-60	A-0	A-60
Stairways (2)	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-30	A-0	A-30
Corridors (3)	A-15	A-0	A-0 [a]	A-60	A-0	A-0	A-15	A-15	A-0	A-0	A-0	A-30	A-0	A-30
Evacuation stations and external escape routes (4)	A-0	A-0	A-0	A-0	-	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Open deck spaces (5)	A-0	A-0	A-0	A-0	-	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of minor fire risk (6)	A-60	A-15	A-0	A-60	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of moderate fire risk (7)	A-60	A-15	A-15	A-60	A-0	A-0	A-15	A-15	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of greater fire risk (8)	A-60	A-15	A-15	A-60	A-0	A-15	A-15	A-30	A-0	A-0	A-0	A-0	A-0	A-0
Sanitary and similar spaces (9)	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Tanks, voids and auxiliary machinery spaces having little or no fire risk (10)	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0 [a]	A-0	A-0	A-0	A-0
Auxiliary machinery spaces, cargo spaces, cargo and other oil tanks and other similar spaces of moderate fire risk (11)	A-60	A-60	A-60	A-60	A-0	A-0	A-15	A-30	A-0	A-0	A-0 [a]	A-0	A-0	A-30
Machinery spaces and main galleys (12)	A-60	A-60	A-60	A-60	A-0	A-60	A-60	A-60	A-0	A-0	A-30	A-30 [a]	A-0	A-60
store-rooms, workshops, pantries etc. (13)	A-60	A-30	A-15	A-60	A-0	A-15	A-30	A-30	A-0	A-0	A-0	A-0	A-0	A-0
Other spaces in which flammable liquids are stowed (14)	A-60	A-60	A-60	A-60	A-0	A-30	A-60	A-60	A-0	A-0	A-0	A-0	A-0	A-0

Note 1: The notes of Table 1.1 apply to Table 1.2, as appropriate.

1.3.2 Bulkheads within a main vertical zone

a) For ships carrying more than 36 passengers, bulkheads which are not required to be A class divisions shall be at least B class or C class divisions as prescribed in Table 1.1 and Table 1.2.

b) For ships carrying not more than 36 passengers, bulkheads within accommodation and service spaces which are not required to be A class divisions shall be at least B class or C class divisions as prescribed in Table 1.3 and Table 1.4. In addition, corridor bulkheads, where not required to be A class, shall be B class divisions which shall extend from deck to deck except:

1) when continuous B class ceilings or linings are fitted on both sides of the bulkhead, the portion of the bulkhead behind the continuous ceiling or lining shall be of material which, in thickness and composition, is acceptable in the construction of B class divisions, but which shall be required to meet B class integrity standards only in so far as is reasonable and practicable in the opinion of the Society; and

2) in the case of a ship protected by an automatic sprinkler system complying with the provisions of Sec 13, the corridor bulkheads may terminate at a ceiling in the corridor provided such bulkheads and ceilings are of B class standard in compliance with 1.3.4. All doors and frames in such bulkheads shall be of non-combustible materials and shall have the same fire integrity as the bulkhead in which they are fitted.

c) Bulkheads required to be B class divisions, except corridor bulkheads as prescribed in item b) above, shall extend from deck to deck and to the shell or other boundaries. However, where a continuous B class ceiling or lining is fitted on both sides of a bulkhead which is at least of the same fire resistance as the adjoining bulkhead, the bulkhead may terminate at the continuous ceiling or lining.

1.3.3 Fire integrity of bulkheads and decks in ships carrying more than 36 passengers

a) In addition to complying with the specific provisions for fire integrity of bulkheads and decks mentioned in 1.3.1 and 1.3.2, the minimum fire integrity of all bulkheads and decks shall be as prescribed in Table 1.1 and Table 1.2. Where, due to any particular structural arrangements in the ship, difficulty is experienced in determining from the tables the minimum fire integrity value of any divisions, such values shall be determined to the satisfaction of the Society.

b) The following requirements shall govern application of Table 1.1 and Table 1.2:

1) Table 1.1 shall apply to bulkheads not bounding either main vertical zones or horizontal zones.

Table 1.2 shall apply to decks not forming steps in main vertical zones nor bounding horizontal zones.

2) For determining the appropriate fire integrity standards to be applied to boundaries between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (14) below.

Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of the present Section, or where it is possible to assign two or more classifications to a space, it shall be treated as a space within the relevant category having the most stringent boundary requirements.

Smaller, enclosed rooms within a space that have less than 30 % communicating openings to that space are considered separate spaces. The fire integrity of the boundary bulkheads and decks of such smaller rooms shall be as prescribed in Table 1.1 and Table 1.2. The title of each category is intended to be typical rather than restrictive. The number in parentheses preceding each category refers to the applicable column or row in the tables.

- (1) Control stations

Spaces containing emergency sources of power and lighting

Wheelhouse and chartroom

Spaces containing the ship’s radio equipment

Fire control stations

Control room for propulsion machinery when located outside the propulsion machinery space

Spaces containing centralized fire alarm equipment

Spaces containing centralized emergency public address system stations and equipment.

- (2) Stairways

Interior stairways, lifts, totally enclosed emergency escape trunks, and escalators (other than those wholly contained within the machinery spaces) for passengers and crew and enclosures thereto

In this connection a stairway which is enclosed at only one level shall be regarded as part of the space from which it is not separated by a fire door.

- (3) Corridors

Passenger and crew corridors and lobbies.

- (4) Evacuation stations and external escape routes

Survival craft stowage area

Open deck spaces and enclosed promenades forming lifeboat and liferaft embarkation and lowering stations

Assembly stations, internal and external

External stairs and open decks used for escape routes

The ship’s side to the waterline in the lightest seagoing condition, superstructure and deckhouse sides situated below and adjacent to the liferaft and evacuation slide embarkation areas.

- (5) Open deck spaces

Open deck spaces and enclosed promenades clear of lifeboat and liferaft embarkation and lowering stations. To be considered in this category, enclosed promenades shall have no significant fire risk, meaning that furnishings shall be restricted to deck furniture. In addition, such spaces shall be naturally ventilated by permanent openings.

Air spaces (the space outside superstructures and deckhouses).

- (6) Accommodation spaces of minor fire risk

Cabins containing furniture and furnishings of restricted fire risk

Offices and dispensaries containing furniture and furnishings of restricted fire risk

Public spaces containing furniture and furnishings of restricted fire risk and having a deck area of less than 50 m^2.

- (7) Accommodation spaces of moderate fire risk Spaces as in category (6) above but containing furniture and furnishings of other than restricted fire risk

Public spaces containing furniture and furnishings of restricted fire risk and having a deck area of 50 m^2 or more

Isolated lockers and small store-rooms in accommodation spaces having areas less than 4 m^2 (in which flammable liquids are not stowed)

Sale shops

Motion picture projection and film stowage rooms

Diet kitchens (containing no open flame)

Cleaning gear lockers (in which flammable liquids are not stowed)

Laboratories (in which flammable liquids are not stowed)

Pharmacies

Small drying rooms (having a deck area of 4 m^2 or less)

Specie rooms

Operating rooms.

- (8) Accommodation spaces of greater fire risk

Public spaces containing furniture and furnishings of other than restricted fire risk and having a deck area of 50 m^2 or more

Barber shops and beauty parlours

Saunas.

- (9) Sanitary and similar spaces

Communal sanitary facilities, showers, baths, water closets, etc.

Small laundry rooms

Indoor swimming pool area

Isolated pantries containing no cooking appliances in accommodation spaces

Private sanitary facilities shall be considered a portion of the space in which they are located.

- (10) Tanks, voids and auxiliary machinery spaces having little or no fire risk

Water tanks forming part of the ship's structure

Voids and cofferdams

Auxiliary machinery spaces which do not contain machinery having a pressure lubrication system and where storage of combustibles is prohibited, such as:

- ventilation and air-conditioning rooms
- windlass room
- steering gear room
- stabiliser equipment room
- electric propulsion motor room
- rooms containing section switchboards and purely electrical equipment other than oilfilled electrical transformers (above 10 kVA)
- shaft alleys and pipe tunnels, and
- spaces for pumps and refrigeration machinery (not handling or using flammable liquids)

Closed trunks serving the spaces listed above

Other closed trunks such as pipe and cable trunks.

- (11) Auxiliary machinery spaces, cargo spaces, cargo and other oil tanks and other similar spaces of moderate fire risk

Cargo oil tanks

Cargo holds, trunkways and hatchways

Refrigerated chambers

Oil fuel tanks (where installed in a separate space with no machinery)

Shaft alleys and pipe tunnels allowing storage of combustibles

Auxiliary machinery spaces as in category (10) which contain machinery having a pressure lubrication system or where storage of combustibles is permitted

Oil fuel filling stations

Spaces containing oil-filled electrical transformers (above 10 kVA)

Spaces containing turbine and reciprocating steam engine driven auxiliary generators and small internal combustion engines of power output up to 110 kW driving generators, sprinkler, drencher or fire pumps, bilge pumps, etc.

Closed trunks serving the spaces listed above.

- (12) Machinery spaces and main galleys Main propulsion machinery rooms (other than electric propulsion motor rooms) and boiler rooms

Auxiliary machinery spaces other than those in categories (10) and (11) which contain internal combustion machinery or other oil-burning, heating or pumping units

Main galleys and annexes

Trunks and casings to the spaces listed above.

- (13) Store-rooms, workshops, pantries, etc.

Main pantries not annexed to galleys

Main laundry

Large drying rooms (having a deck area of more than 4 m2)

Miscellaneous stores

Mail and baggage rooms

Garbage rooms

Workshops (not part of machinery spaces, galleys, etc.)

Lockers and store-rooms having areas greater than 4 m^2, other than those spaces that have provisions for the storage of flammable liquids.

- (14) Other spaces in which flammable liquids are stowed

Paint lockers

store-rooms containing flammable liquids (including dyes, medicines, etc.)

Laboratories (in which flammable liquids are stowed).

3) Notwithstanding the provisions of 1.3.2, there are no special requirements for material or integrity of boundaries where only a dash appears in the tables.

4) The Society shall determine in respect of category (5) spaces whether the insulation values in Table 1.1 shall apply to ends of deckhouses and superstructures, and whether the insulation values in Table 1.2 shall apply to weather decks. In no case shall the requirements of category (5) of Table 1.1 or Table 1.2 necessitate enclosure of spaces which in the opinion of the Society need not be enclosed.

c) Continuous B class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing, wholly or in part, to the required insulation and integrity of a division.

d) In approving structural fire protection details, the Society shall have regard to the risk of heat transmission at intersections and terminal points of required thermal barriers.

e) Construction and arrangement of saunas

- The perimeter of the sauna shall be of “A” class boundaries and may include changing rooms, showers and toilets. The sauna shall be insulated to “A- 60” standard against other spaces except those inside the perimeter and spaces of categories (5), (9) and (10).

- Bathrooms with direct access to saunas may be considered as part of them. In such cases, the door between sauna and the bathroom need not comply with fire safety requirements.
- The traditional wooden lining on the bulkheads and ceiling are permitted in the sauna. The ceiling above the oven shall 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 shall be at least 500 mm or the combustible materials shall be protected (e.g. non-combustible plate with an air gap of at least 30 mm).
- The traditional wooden benches are permitted to be used in the sauna.
- The sauna door shall open outwards by pushing.
- Electrically heated ovens shall be provided with a timer.

Note 1: For the purpose of this Section, hamans are treated as saunas.

1.3.4 Fire integrity of bulkheads and decks in ships carrying not more than 36 passengers

a) In addition to complying with the specific provisions for fire integrity of bulkheads and decks mentioned in 1.3.1 and 1.3.2, the minimum fire integrity of bulkheads and decks shall be as prescribed in Table 1.3 and Table 1.4.

b) The following requirements govern application of the tables:

1) Table 1.3 and Table 1.4 shall apply, respectively, to the bulkheads and decks separating adjacent spaces.

2) For determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (11) below.

Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of the present Section, or where it is possible to assign two or more classifications to a space, it shall be treated as a space within the relevant category having the most stringent boundary requirements. Smaller, enclosed rooms within a space that have less than 30 % communicating openings to that space are considered separate spaces. The fire integrity of the boundary bulkheads and decks of such smaller rooms shall be as prescribed in Table 1.3 and Table 1.4. The title of each category is intended to be typical rather than restrictive. The number in parentheses preceding each category refers to the applicable column or row in the tables.

- (1) Control stations

Spaces containing emergency sources of power and lighting

Wheelhouse and chartroom

Spaces containing the ship’s radio equipment

Fire control stations

Control room for propulsion machinery when located outside the machinery space

Spaces containing centralized fire alarm equipment.

- (2) Corridors

Passenger and crew corridors and lobbies.

- (3) Accommodation spaces

Spaces as defined in Sec 1, 3.1 excluding corridors.

(4) Stairways

Interior stairways, lifts, totally enclosed emergency escape trunks, and escalators (other than those wholly contained within the machinery paces) and enclosures thereto

In this connection, a stairway which is enclosed only at one level shall be regarded as part of the space from which it is not separated by a fire door.

- (5) Service spaces (low risk)

Lockers and store-rooms not having provisions for the storage of flammable liquids and having areas less than 4 m^2 and drying rooms and laundries.

- (6) Machinery spaces of category A

Spaces as defined in Sec 1, 3.24.

- (7) Other machinery spaces

Electrical equipment rooms (auto-telephone exchange, air-conditioning duct spaces)

Spaces as defined in Sec 1, 3.23, excluding machinery spaces of category A.

- (8) Cargo spaces

All spaces used for cargo (including cargo oil tanks) and trunkways and hatchways to such spaces, other than special category spaces.

- (9) Service spaces (high risk)

Galleys, pantries containing cooking appliances, paint lockers, lockers and store-rooms having areas of 4 m^2 or more, spaces for the storage of flammable liquids, saunas and workshops other than those forming part of the machinery spaces.

- (10) Open decks

Open deck spaces and enclosed promenades having little or no fire risk. Enclosed promenades shall have no significant fire risk, meaning that furnishing shall be restricted to deck furniture. In addition, such spaces shall be naturally ventilated by permanent openings

Air spaces (the space outside superstructures and deckhouses).

- (11) Special category and ro-ro spaces

Spaces as defined in Sec 1, 3.34 and Sec 1, 3.38.

3) In determining the applicable fire integrity standard of a boundary between two spaces within a main vertical zone or horizontal zone which is not protected by an automatic sprinkler system complying with the provisions of Sec 13 or

between such zones neither of which is so protected, the higher of the two values given in the tables shall apply.

4) In determining the applicable fire integrity standard of a boundary between two spaces within a main vertical zone or horizontal zone which is protected by an automatic sprinkler system complying with the provisions of Sec 13 or between such zones both of which are so protected, the lesser of the two values given in the tables shall apply. Where a zone with sprinklers and a zone without sprinklers meet within accommodation and service spaces, the higher of the two values given in the tables shall apply to the division between the zones.

c) Continuous B class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing, wholly or in part, to the required insulation and integrity of a division.

d) External boundaries which are required in Sec 7, 2.1.1 to be of steel or other equivalent material may be pierced for the fitting of windows and side scuttles provided that there is no requirement for such boundaries of passenger ships to have A class integrity. Similarly, in such boundaries which are not required to have A class integrity, doors may be constructed of materials which are to the satisfaction of the Society.

e) In approving structural fire protection details, the Society shall have regard to the risk of heat transmission at intersections and terminal points of required thermal barriers.

f) Saunas shall comply with 1.3.3, item e).

1.3.5 Protection of stairways and lifts in accommodation area

a) Stairways shall be within enclosures formed of A class divisions, with positive means of closure at all openings, except that:

1) a stairway connecting only two decks need not be enclosed, provided the integrity of the deck is maintained by proper bulkheads or self-closing doors in one ’tweendeck space. When a stairway is closed in one ’tweendeck space, the stairway enclosure shall be protected in accordance with the tables for decks in 1.3.3 or 1.3.4.

The door provided at this stairway enclosure is to be of the self-closing type.

2) stairways may be fitted in the open in a public space, provided they lie wholly within the public space.

b) Lift trunks shall be so fitted as to prevent the passage of smoke and flame from one ’tweendeck to another and shall be provided with means of closing so as to permit the control of draught and smoke. Machinery for lifts located within stairway enclosures shall be arranged in a separate room, surrounded by steel boundaries, except that small passages for lift cables are permitted. Lifts which open into spaces other than corridors, public spaces, special category spaces, stairways and external areas shall not open into stairways included in the means of escape.

1.3.6 Arrangement of cabin balconies

Non-load bearing partial bulkheads which separate adjacent cabin balconies shall be capable of being opened by the crew from each side for the purpose of fighting fires.

Table 1.3: Fire integrity of bulkheads separating adjacent spaces in passenger ships carrying not more than 36 passengers

Spaces	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations (1)	A-0[c]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*	A-60
Corridors (2)		C[e]	B-0[e]	A-0[a] B-0[e]	B-0[e]	A-60	A-0	A-0	A-15 A-0[d]	*	A-15
Accommodation spaces (3)			C[e]	A-0[a] B-0[e]	B-0[e]	A-60	A-0	A-0	A-15 A-0[d]	*	A-30 A-0[d]
Stairways (4)				A-0[a] B-0[e]	A-0[a] B-0[e]	A-60	A-0	A-0	A-15 A-0[d]	*	A-15
Service spaces (low risk) (5)					C[e]	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A (6)						*	A-0	A-0	A-60	*	A-60
Other machinery spaces (7)							A-0[b]	A-0	A-0	*	A-0
Cargo spaces (8)								*	A-0	*	A-0
Service spaces (high risk) (9)									A-0[b]	*	A-30
Open decks (10)										-	A-0
Special category and ro-ro spaces (11)											A-0

Note 1: (to be applied to Table 1.3 and Table 1.4, as appropriate)

[a] : For clarification as to which applies, see 1.3.2 and 1.3.5.

[b] : Where spaces are of the same numerical category and letter "b" appears, a bulkhead or deck of the rating shown in the tables is only required when the adjacent spaces are for a different purpose, e.g. in category (9). A galley next to a galley does not require a bulkhead, but a galley next to a paint room requires an A-0 bulkhead.

[c] : Bulkheads separating the wheelhouse and chartroom from each other may have a B-0 rating.

[d] : See items b) 3) and b) 4) of 1.3.4.

[e] : For the application of item b) of 1.3.1, B-0 and C, where appearing in Table 1.3, are to be read as A-0.

[f] : Fire insulation need not be fitted if the machinery space in category (7), in the opinion of the Society, has little or no fire risk.

* : Where an asterisk appears in the tables, the division is required to be of steel or other equivalent material, but is not required to be of A class standard. However, where a deck, except in a category (10) space, is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be made tight to prevent the passage of flamme and smoke. Divisions between control stations (emergency generators) and open decks may have air intake openings without means for closure, unless a fixed gas fire-extinguishing system is fitted.

For the application of item b) of 1.3.1, an asterisk, where appearing in Tab 1.4, except for categories (8) and (10), is to be read as A-0.

Table 1.4: Fire integrity of decks separating adjacent spaces in passenger ships carrying not more than 36 passengers

Spaces Below	Spaces Below										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations (1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0	*	A-30
Corridors (2)	A-0	*	*	A-0	*	A-60	A-0	A-0	A-0	*	A-0
Accommodation spaces (3)	A-60	A-0	*	A-0	*	A-60	A-0	A-0	A-0	*	A-30 A-0[d]
Stairways (4)	A-0	A-0	A-0	*	A-0	A-60	A-0	A-0	A-0	*	A-0
Service spaces (low risk) (5)	A-15	A-0	A-0	A-0	*	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A (6)	A-60	A-60	A-60	A-60	A-60	*	A-60[f]	A-30	A-60	*	A-60
Other machinery spaces (7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*	A-0
Cargo spaces (8)	A-60	A-0	A-0	A-0	A-0	A-0	A-0	*	A-0	*	A-0
Service spaces (high risk) (9)	A-60	A-30 A-0[d]	A-30 A-0[d]	A-30 A-0[d]	A-0	A-60	A-0	A-0	A-0	*	A-30
Open decks (10)	*	*	*	*	*	*	*	*	*	–	A-0
Special category and ro-ro spaces (11)	A-60	A-15	A-30 A-0[d]	A-15	A-0	A-30	A-0	A-0	A-30	A-0	A-0

Note 1: The notes to Table 1.3 apply to this table as appropriate.

1.4 Cargo ships except tankers

1.4.1 Methods of protection in accommodation area

a) One of the following methods of protection shall be adopted in accommodation and service spaces and control stations:

1) Method IC

The construction of internal divisional bulkheads of non-combustible B or C class divisions generally without the installation of an automatic sprinkler, fire detection and fire alarm system in the accommodation and service spaces, except as required by item a) of Sec 3, 4.6.1, or

2) Method IIC

The fitting of an automatic sprinkler, fire detection and fire alarm system as required by item b) of Ch 4, Sec 3, [4.6.1] for the detection and extinction of fire in all spaces in which fire might be expected to originate, generally with no restriction on the type of internal divisional bulkheads, or

3) Method IIIC

The fitting of a fixed fire detection and fire alarm system, as required by item c) of Sec 3, 4.6.1, in spaces in which a fire might be expected to originate, generally with no restriction on the type of internal divisional bulkheads, except that in no case shall the area of any accommodation space or spaces bounded by an A or B class division exceed 50 m^2 . However, consideration may be given by the Society to increasing this area for public spaces.

b) The requirements for the use of non-combustible materials in the construction and insulation of boundary bulkheads of machinery spaces, control stations, service spaces, etc., and the protection of the above stairway enclosures and corridors will be common to all three methods outlined in a).

c) In approving structural fire protection details, the Society shall have regard to the risk of heat transmission at intersections and terminal points of required thermal barriers.

Table 1.5: Fire integrity of bulkheads separating adjacent spaces in cargo ships

Spaces	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations (1)	A-0[e]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*	A-60
Corridors (2)		C	B-0	A-0[c] B-0	B-0	A-60	A-0	A-0	A-0	*	A-30
Accommodation spaces (3)			C[a,b]	A-0[c] B-0	B-0	A-60	A-0	A-0	A-0	*	A-30
Stairways (4)				A-0[c] B-0	A-0[c] B-0	A-60	A-0	A-0	A-0	* *	A-30
Service spaces (low risk) (5)					C	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A (6)						*	A-0	A-0[g]	A-60	*	A-60[f]
Other machinery spaces (7)							A-0[d]	A-0	A-0	*	A-0
Cargo spaces (8)								*	A-0	*	A-0
Service spaces (high risk) (9)									A-0[d]	*	A-30
Open decks (10)										–	A-0
Ro-ro and vehicle spaces (11)											*[h]

Note 1: (to be applied to Table 1.5 and Table 1.6, as appropriate)

[a] : No special requirements are imposed upon bulkheads in methods IIC and IIIC fire protection.

[b] : In case of method IIIC, B class bulkheads of B-0 rating are to be provided between spaces or groups of spaces of 50m2 and over in area.

[c] : For clarification as to which applies, see 1.4.2 and 1.4.4.

[d] : Where spaces are of the same numerical category and letter “d” appears, a bulkhead or deck of the rating shown in the tables is only required when the adjacent spaces are for a different purpose, e.g. in category (9). A galley next to a galley does not require a bulkhead, but a galley next to a paint room requires an A-0 bulkhead.

[e] : Bulkheads separating the wheelhouse, chartroom and radio room from each other may have a B-0 rating.

[f] : An A-0 rating may be used if no dangerous goods are intended to be carried or if such goods are stowed not less than 3 m horizontally from such a bulkhead.

[g] : For cargo spaces in which dangerous goods are intended to be carried, Sec 11, 2.9 applies.

[h] : Bulkheads and decks separating ro-ro spaces are to be capable of being closed reasonably gastight and such divisions are to have A class integrity in so far as reasonable and practicable, if in the opinion of the Society it has little or no fire risk.

[i] : Fire insulation need not be fitted in the machinery space in category (7) if, in the opinion of the Society, it has little or no fire risk.

* : Where an asterisk appears in the tables, the division is required to be of steel or other equivalent material but is not required to be of A class standard. However where a deck, except an open deck, is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be made tight to prevent the passage of flamme and smoke. Divisions between control stations (emergency generators) and open decks may have air intake openings without means for closure, unless a fixed gas fire-extinguishing system is fitted.

Table1. 6: Fire integrity of decks separating adjacent spaces in cargo ships

Spaces Below	Spaces Below										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations (1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0	*	A-60
Corridors (2)	A-0	*	*	A-0	*	A-60	A-0	A-0	A-0	*	A-30
Accommodation spaces (3)	A-60	A-0	*	A-0	*	A-60	A-0	A-0	A-0	*	A-30
Stairways (4)	A-0	A-0	A-0	*	A-0	A-60	A-0	A-0	A-0	*	A-30
Service spaces (low risk) (5)	A-15	A-0	A-0	A-0	*	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A (6)	A-60	A-60	A-60	A-60	A-60	*	A-60[i]	A-30	A-60	*	A-60
Other machinery spaces (7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*	A-0
Cargo spaces (8)	A-60	A-0	A-0	A-0	A-0	A-0	A-0	*	A-0	*	A-0
Service spaces (high risk) (9)	A-60	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0[d]	*	A-30
Open decks (10)	*	*	*	*	*	*	*	*	*	–	*
Special category and ro-ro spaces (11)	A-60	A-30	A-30	A-30	A-0	A-60	A-0	A-0	A-30	*	*[h]

Note 1: The notes to Tab 1.5 apply to this Table as appropriate.

1.4.2 Bulkheads within accommodation area

a) Bulkheads required to be B class divisions shall extend from deck to deck and to the shell or other boundaries.

However, where a continuous B class ceiling or lining is fitted on both sides of the bulkhead, the bulkhead may terminate at the continuous ceiling or lining.

b) Method IC

Bulkheads not required by this or other Sections for cargo ships to be A or B class divisions shall be of at least C class construction.

c) Method IIC

There shall be no restriction on the construction of bulkheads not required by this or other Sections for cargo ships to be A or B class divisions except in individual cases where C class bulkheads are required in accordance with Table 1.5.

d) Method IIIC

There shall be no restriction on the construction of bulkheads not required for cargo ships to be A or B class divisions except that the area of any accommodation space or spaces bounded by a continuous A or B class division shall in no case exceed 50 m^2, except in individual cases where C class bulkheads are required in accordance with Table 1.5. However, consideration may be given by the Society to increasing this area for public space.

1.4.3 Fire integrity of bulkheads and decks

a) In addition to complying with the specific provisions for fire integrity of bulkheads and decks of cargo ships, the minimum fire integrity of bulkheads and decks shall be as prescribed in Table 1.5 and Table 1.6.

b) The following requirements shall govern application of Table 1.5 and Table 1.6:

1) Table 1.5 and Table 1.6 shall apply respectively to the bulkheads and decks separating adjacent spaces.

2) For determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (11) below.

Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of the present Section, or where it is possible to assign two or more classifications to a space, it shall be treated as a space within the relevant category having the most stringent boundary requirements.

Smaller, enclosed rooms within a space that have less than 30 % communicating openings to that space are considered separate spaces. The fire integrity of the boundary bulkheads and decks of such smaller rooms shall be as prescribed in Table 1.5 and Table 1.6. The title of each category is intended to be typical rather than restrictive. The number in parentheses preceding each category refers to the applicable column or row in the tables.

- (1) Control stations

Spaces containing emergency sources of power and lighting

Wheelhouse and chartroom

Spaces containing the ship’s radio equipment

Fire control stations

Control room for propulsion machinery when located outside the machinery space

Spaces containing centralised fire alarm equipment.

- (2) Corridors

Corridors and lobbies.

- (3) Accommodation spaces

Spaces as defined in Sec 1, 3.1, excluding corridors.

- (4) Stairways

Interior stairways, lifts, totally enclosed emergency escape trunks, and escalators (other than those wholly contained within the machinery spaces) and enclosures thereto

In this connection, a stairway which is enclosed only at one level shall be regarded as part of the space from which it is not separated by a fire door.

- (5) Service spaces (low risk)

Lockers and store-rooms not having provisions for the storage of flammable liquids and having areas less than 4 m^2 and drying rooms and laundries.

- (6) Machinery spaces of category A

Spaces as defined in Sec 1, 3.24.

- (7) Other machinery spaces

Electrical equipment rooms (auto-telephone exchange, air-conditioning duct spaces)

Spaced as defined in Sec 1, 3.23, excluding machinery spaces of category A.

- (8) Cargo spaces

All spaces used for cargo (including cargo oil tanks) and trunkways and hatchways to such spaces.

- (9) Service spaces (high risk)

Galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 m^2 or more, spaces for the storage of flammable liquids, and workshops other than those forming part of the machinery spaces.

- (10) Open decks

Open deck spaces and enclosed promenades having little or no fire risk. To be considered in this category, enclosed promenades shall have no significant fire risk, meaning that furnishings shall be restricted to deck furniture. In addition, such spaces shall be naturally ventilated by permanent openings

Air spaces (the space outside superstructures and deckhouses).

- (11) Ro-ro and vehicle spaces

Ro-ro spaces as defined in Sec 1, 3.34

Vehicle spaces as defined in Sec 1, 3.41.

3) Continuous B class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing, wholly or in part, to the required insulation and integrity of a division.

4) External boundaries which are required in Sec 7, 2.1.1 to be of steel or other equivalent material may be pierced for the fitting of windows and side scuttles provided that there is no requirement for such boundaries of cargo ships to have A class integrity.

Similarly, in such boundaries which are not required to have A class integrity, doors may be constructed of materials which are to the satisfaction of the Society.

c) Saunas shall comply with 1.3.3, item e).

1.4.4 Protection of stairways and lift trunks in accommodation spaces, service spaces and control stations

a) Stairways which penetrate only a single deck shall be protected, at a minimum, at one level by at least B-0 class divisions and self-closing doors. Lifts which penetrate only a single deck shall be surrounded by A-0 class divisions with steel doors at both levels. Stairways and lift trunks which penetrate more than a single deck shall be surrounded by at least A-0 class divisions and be protected by self-closing doors at all levels.

Dumb-waiters are to be regarded as lifts.

b) On ships having accommodation for 12 persons or less, where stairways penetrate more than a single deck and where there are at least two escape routes direct to the open deck at every accommodation level, the A-0 requirements of the above item a) may be reduced to B-0.

1.5 Tankers

1.5.1 Application

For tankers, only method IC as defined in item a) of 1.4.1 shall be used.

1.5.2 Fire integrity of bulkheads and decks

a) In lieu of the requirements of 1.4 and in addition to complying with the specific provisions for fire integrity of bulkheads and decks of tankers, the minimum fire integrity of bulkheads and decks shall be as prescribed in Table 1.7 and Table 1.8.

b) The following requirements shall govern application of Table 1.7 and Table 1.8:

1) Table 1.7 and Table 1.8 shall apply respectively to the bulkheads and decks separating adjacent spaces.

2) For determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (10) below.

Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of the present Section, or where it is possible to assign two or more classifications to a space, it shall be treated as a space within the relevant category having the most stringent boundary requirements.

Smaller, enclosed areas within a space that have less than 30 % communicating openings to that space are considered separate areas. The fire integrity of the boundary bulkheads and decks of such smaller spaces shall be as prescribed in Table 1.7 and Table 1.8.

The title of each category is intended to be typical rather than restrictive. The number in parentheses preceding each category refers to the applicable column or row in the tables.

- (1) Control stations

Spaces containing emergency sources of power and lighting

Wheelhouse and chartroom

Spaces containing the ship's radio equipment

Fire control stations

Control room for propulsion machinery when located outside the machinery space

Spaces containing centralized fire alarm equipment.

- (2) Corridors

Corridors and lobbies.

- (3) Accommodation spaces

Spaces as defined in Sec 1, 3.1, excluding corridors.

- (4) Stairways

Interior stairways, lifts, totally enclosed emergency escape trunks, and escalators (other than those wholly contained within the machinery spaces) and enclosures thereto

In this connection a stairway which is enclosed only at one level shall be regarded as part of the space from which it is not separated by a fire door.

- (5) Service spaces (low risk)

Lockers and store-rooms not having provisions for the storage of flammable liquids and having areas less than 4 m2 and drying rooms and laundries.

- (6) Machinery spaces of category A

Spaces as defined in Sec 1, 3.24.

- (7) Other machinery spaces

Electrical equipment rooms (auto-telephone exchange and air-conditioning duct spaces)

Spaces as defined in Sec 1, 3.23, excluding machinery spaces of category A.

- (8) Cargo pump-rooms

Spaces containing cargo pumps and entrances and trunks to such spaces.

- (9) Service spaces (high risk)

Galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 m^2 or more, spaces for the storage of flammable liquids and workshops other than those forming part of the machinery spaces.

- (10) Open decks

Open deck spaces and enclosed promenades having little or no fire risk. To be considered in this category, enclosed promenades shall have no significant fire risk, meaning that furnishings shall be restricted to deck furniture. In addition, such spaces shall be naturally ventilated by permanent openings Air spaces (the space outside superstructures and deckhouses).

c) Continuous B class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing, wholly or in part, to the required insulation and integrity of a division.

d) External boundaries which are required in Sec 7, 2.1.1 to be of steel or other equivalent material may be pierced for the fitting of windows and sidescuttles provided that there is no requirement for such boundaries of tankers to have A class integrity. Similarly, in such boundaries which are not required to have A class integrity, doors may be constructed of materials which are to the satisfaction of the Society.

e) Exterior boundaries of superstructures and deckhouses enclosing accommodation and including any overhanging decks which support such accommodation shall be constructed of steel and insulated to A-60 standard for the whole of the portions which face the cargo area and on the outward sides for a distance of 3 m from the end boundary facing the cargo area. The distance of 3 m shall be measured horizontally and parallel to the middle line of the ship from the boundary which faces the cargo area at each deck level. In the case of the sides of those superstructures and deckhouses, such insulation shall be carried up to the underside of the deck of the navigation bridge.

Windows and side scuttles within these limits are to be of the fixed type and constructed to the A-60 standard.

f) Skylights to cargo pump-rooms shall be of steel, shall not contain any glass and shall be capable of being closed from outside the pump-room.

g) In approving structural fire protection details, the Society shall have regard to the risk of heat transmission at intersections and terminal points of required thermal barriers.

h) Saunas shall comply with 1.3.3, item e).

Table 1.7: Fire integrity of bulkheads separating adjacent spaces in tankers

Spaces	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations (1)	A-0[c]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*
Corridors (2)		C	B-0	A-0[a] B-0	B-0	A-60	A-0	A-60	A-0	*
Accommodation spaces (3)			C	A-0[a] B-0	B-0	A-60	A-0	A-60	A-0	*
Stairways (4)				A-0[a] B-0	A-0[a] B-0	A-60	A-0	A-60	A-0	*
Service spaces (low risk) (5)					C	A-60	A-0	A-60	A-0	*
Machinery spaces of category A (6)						*	A-0	A-0[d]	A-60	*
Other machinery spaces (7)							A-0[b]	A-0	A-0	*
Cargo pump rooms (8)								*	A-60	*
Service spaces (high risk) (9)									A-0[b]	*
Open decks (10)										–

Note 1: (to be applied to Table 1.7 and Table 1.8, as appropriate)

[a] : For clarification as to which applies, see 1.4.2 and 1.4.4.

[b] : Where spaces are of the same numerical category and letter “b” appears, a bulkhead or deck of the rating shown in the tables is only required when the adjacent spaces are for a different purpose, e.g. in category (9). A galley next to a galley does not require a bulkhead, but a galley next to a paint room requires an A-0 bulkhead.

[c] : Bulkheads separating the wheelhouse, chartroom and radio room from each other may have a B-0 rating.

[d] : Bulkheads and decks between cargo pump-rooms and machinery spaces of category A may be penetrated by cargo pump shaft glands and similar gland penetrations, provided that gastight seals with efficient lubrication or other means of ensuring the permanence of the gas seal are fitted in way of the bulkheads or decks.

[e] : Fire insulation need not be fitted in the machinery space in category (7) if, in the opinion of the Society, it has little or no fire risk.

* : Where an asterisk appears in the tables, the division is required to be of steel or other equivalent material, but is not required to be of A class standard. However, where a deck, except an open deck, is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be made tight to prevent the passage of flame and smoke. Divisions between control stations (emergency generators) and open decks may have air intake openings without means for closure, unless a fixed gas fire-extinguishing system is fitted.

Table 1.8: Fire integrity of decks separating adjacent spaces in tankers

Spaces Below	Spaces Below									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations (1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	-	A-0	*
Corridors (2)	A-0	*	*	A-0	*	A-60	A-0	-	A-0	*
Accommodation spaces (3)	A-60	A-0	*	A-0	*	A-60	A-0	-	A-0	*
Stairways (4)	A-0	A-0	A-0	*	A-0	A-60	A-0	-	A-0	*
Service spaces (low risk) (5)	A-15	A-0	A-0	A-0	*	A-60	A-0	-	A-0	*
Machinery spaces of category A (6)	A-60	A-60	A-60	A-60	A-60	*	A-60[e]	A-0	A-60	*
Other machinery spaces (7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*
Cargo pump-rooms (8)	-	-	-	-	-	A-0 [d]	A-0	*	-	*
Service spaces (high risk) (9)	A-60	A-0	A-0	A-0	A-0	A-60	A-0	-	A-0 [b]	*
Open decks (10)	*	*	*	*	*	*	*	*	*	–

Note 1: The notes to Tab 1.7 apply to this Table as appropriate.

2 Penetrations in fire-resisting divisions and prevention of heat transmission

2.1 Penetrations in A class divisions

2.1.1 Where A class divisions are penetrated, such penetration shall be tested in accordance with the Fire Test Procedures Code. In the case of ventilation ducts, requirements 6.2.2 and 6.4.1 apply. However, where a pipe penetration is made of steel or equivalent material having a thickness of 3 mm or greater and a length of not less than 900 mm (preferably 450 mm on each side of the division), and there are no openings, testing is not required. Such penetrations shall be suitably insulated by extension of the insulation at the same level of the division.

2.2 Penetrations in B class divisions

2.2.1 Where B class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., of for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements shall be made to ensure that the fire resistance is not impaired, subject to the provisions of paragraph 6.4.3. Pipes other than steel or copper that penetrate B class divisions shall be protected by either:

- a fire-tested penetration device suitable for the fire resistance of the division pierced and the type of pipe used, or
- a steel sleeve, having a thickness of not less than 1,8 mm and a length of not less than 900 mm for pipe diameters of 150 mm or more and not less than 600 mm for pipe diameters of less than 150 mm (preferably equally divided to each side of the division). The pipe shall be connected to the ends of the sleeve by flanges or couplings; or the clearance between the sleeve and the pipe shall not exceed 2,5 mm; or any clearance between pipe and sleeve shall be made tight by means of noncombustible or other suitable material.

2.3 Pipes penetrating A or B class divisions

2.3.1 Uninsulated metallic pipes penetrating A or B class divisions shall be of materials having a melting temperature which exceeds 950°C for A-0 and 850°C for B-0 class divisions.

2.3.2 Where the Society may permit the conveying of oil and combustible liquids through accommodation and service spaces, the pipes conveying oil or combustible liquids shall be of a material approved by the Society having regard to the fire risk.

2.4 Prevention of heat transmission

2.4.1 In approving structural fire protection details, the Administration shall have regard to the risk of heat transmission at intersections and terminal points of required thermal barriers. The insulation of a deck or bulkhead shall be carried past the penetration, intersection or terminal point for a distance of at least 450 mm in the case of steel and aluminium structures. If a space is divided with a deck or a bulkhead of A class standard having insulation of different values, the insulation with the higher value shall continue on the deck or bulkhead with the insulation of the lesser value for a distance of at least 450 mm.

3 Protection of openings in fireresisting divisions

3.1 Application

3.1.1 The provisions of 3.2 apply to passenger ships and those of 3.3 apply to cargo ships.

3.2 Openings in bulkheads and decks

3.2.1 Openings in A class divisions

a) Except for hatches between cargo, special category, store and baggage spaces, and between such spaces and the weather decks, openings shall be provided with permanently attached means of closing which shall be at least as effective for resisting fires as the divisions in which they are fitted.

b) The construction of doors and door frames in A class divisions, with the means of securing them when closed, shall provide resistance to fire as well as to the passage of smoke and flame equivalent to that of the bulkheads in which the doors are situated, this being determined in accordance with the Fire Test Procedures Code. Such doors and door frames shall be constructed of steel or other equivalent material. Watertight doors need not be insulated.

c) It shall be possible for each door to be opened and closed from each side of the bulkhead by one person only.

d) Fire doors in main vertical zone bulkheads, galley boundaries and stairway enclosures other than poweroperated watertight doors and those which are normally locked shall satisfy the following requirements:

1) the doors shall be self-closing and be capable of closing with an angle of inclination of up to 3.5° opposing closure
2) the approximate time of closure for hinged fire doors shall be no more than 40 s and no less than 10 s from the beginning of their movement with the ship in upright position. The approximate uniform rate of closure for sliding doors shall be of no more than 0.2 m/s and no less than 0.1 m/s with the ship in upright position
3) the doors, except those for emergency escape trunks, shall be capable of remote release from the continuously manned central control station, either simultaneously or in groups, and shall be capable of release also individually from a position at both sides of the door. Release switches shall have an on-off function to prevent automatic resetting of the system
4) hold-back hooks not subject to central control station release are prohibited
5) a door closed remotely from the central control station shall be capable of being re-opened from both sides of the door by local control. After such local opening, the door shall automatically close again
6) indication shall be provided at the fire door indicator panel in the continuously manned central control station whether each door is closed
7) the release mechanism shall be so designed that the door will automatically close in the event of disruption of the control system or central power supply
8) local power accumulators for power-operated doors shall be provided in the immediate vicinity of the doors to enable the doors to be operated at least ten times (fully opened and closed) after disruption of the control system or central power supply using the local controls
9) disruption of the control system or central power supply at one door shall not impair the safe functioning of the other doors
10) remote-released sliding or power-operated doors shall be equipped with an alarm that sounds at least 5 s but no more than 10 s, after the door is released

from the central control station and before the door begins to move and continues sounding until the door is completely closed

11) a door designed to re-open upon contacting an object in its path shall re-open not more than 1 m from the point of contact

12) double-leaf doors equipped with a latch necessary for their fire integrity shall have a latch that is automatically activated by the operation of the doors when released by the system

13) doors giving direct access to special category spaces which are power-operated and automatically closed need not be equipped with the alarms and remoterelease mechanisms required in items 3) and 10)

14) the components of the local control system shall be accessible for maintenance and adjusting

15) power-operated doors shall be provided with a control system of an approved type which shall be able to operate in case of fire and be in accordance with the Fire Test Procedures Code. This system shall satisfy the following requirements:

- the control system shall be able to operate the door at the temperature of at least 200°C for at least 60 min, served by the power supply
- the power supply for all other doors not subject to fire shall not be impaired, and
- at temperatures exceeding 200°C, the control system shall be automatically isolated from the power supply and shall be capable of keeping the door closed up to at least 945°C.

e) The requirements for A class integrity of the outer boundaries of a ship shall not apply to glass partitions, windows and side scuttles, provided that there is no requirement for such boundaries to have A class integrity in item c) of 3.2.3. The requirements for A class integrity of the outer boundaries of the ship shall not apply to exterior doors, except for those in superstructures and deckhouses facing life-saving appliances, embarkation and external assembly station areas, external stairs and open decks used for escape routes. Stairway enclosure doors need not meet this requirement.

f) Except for watertight doors, weathertight doors (semi watertight doors), doors leading to the open deck and doors which need to be reasonably gas-tight, all A class doors located in stairways, public spaces and main vertical zone bulkheads in escape routes shall be equipped with a self-closing hose port. The material, construction and fire resistance of the hose port shall be equivalent to the door into which it is fitted, and shall be a 150 mm square clear opening with the door closed and shall be inset into the lower edge of the door, opposite the door hinges or, in the case of sliding doors, nearest the opening.

3.2.2 Openings in B class divisions

a) Doors and door frames in B class divisions and means of securing them shall provide a method of closure which shall have resistance to fire equivalent to that of the divisions, this being determined in accordance with the Fire Test Procedures Code, except that ventilation openings may be permitted in the lower portion of such doors.

Where such opening is in or under a door, the total net area of any such opening or openings shall not exceed 0.05 m2. Alternatively, a non-combustible air balance duct routed between the cabin and the corridor, and located below the sanitary unit, is permitted where the cross-sectional area of the duct does not exceed 0.05 m2. All ventilation openings shall be fitted with a grill made of non-combustible material. Doors shall be noncombustible.

b) Cabin doors in B class divisions shall be of a self-closing type. Hold-back hooks are not permitted.

c) The requirements for B class integrity of the outer boundaries of a ship shall not apply to glass partitions, windows and side scuttles. Similarly, the requirements for B class integrity shall not apply to exterior doors in superstructures and deckhouses. For ships carrying not more than 36 passengers, the Society may permit the use of combustible materials in doors separating cabins from the individual interior sanitary spaces such as showers.

3.2.3 Windows and side scuttles

a) Windows and side scuttles in bulkheads within accommodation and service spaces and control stations other than those to which the provisions of item e) of 3.2.1 and item c) of 3.2.2 apply shall be so constructed as to preserve the integrity requirements of the type of bulkheads in which they are fitted, this being determined in accordance with the Fire Test Procedures Code.

b) Notwithstanding the requirements of Table 1.1 to Table 1.4, windows and sidescuttles in bulkheads separating accommodation and service spaces and control stations from weather shall be constructed with frames of steel or other suitable material. The glass shall be retained by a metal glazing bead or angle.

c) Windows facing life-saving appliances, embarkation and assembly stations, external stairs and open decks used for escape routes, and windows situated below liferaft and escape slide embarkation areas shall have fire integrity as required in Tab 1.1. Where automatic dedicated sprinkler heads are provided for windows, A-0 windows may be accepted as equivalent. To be considered under this paragraph, the sprinkler heads shall either be:

1) dedicated heads located above the windows, and installed in addition to the conventional ceiling sprinklers; or

2) conventional ceiling sprinkler heads arranged such that the window is protected by an average application rate of at least 5 l/m2 and the additional window area is included in the calculation of the area of coverage.

Windows located in the ship’s side below the lifeboat embarkation area shall have fire integrity at least equal to A-0 class.

3.3 Doors in fire-resisting divisions

3.3.1 The fire resistance of doors shall be equivalent to that of the division in which they are fitted, this being determined in accordance with the Fire Test Procedures Code.

Doors and door frames in A class divisions shall be constructed of steel. Doors in B class divisions shall be noncombustible. Doors fitted in boundary bulkheads of machinery spaces of category A shall be reasonably gastight and self-closing. In ships constructed according to method IC, the Society may permit the use of combustible materials in doors separating cabins from individual interior sanitary accommodation such as showers.

3.3.2 Doors required to be self-closing shall not be fitted with hold-back hooks. However, hold-back arrangements fitted with remote release devices of the fail-safe type may be utilized.

3.3.3 In corridor bulkheads, ventilation openings may be permitted in and under the doors of cabins and public spaces. Ventilation openings are also permitted in B class doors leading to lavatories, offices, pantries, lockers and store-rooms. Except as permitted below, the openings shall be provided only in the lower half of a door. Where such an opening is in or under a door, the total net area of any such opening or openings shall not exceed 0.05 m^2. Alternatively, a non-combustible air balance duct routed between the cabin and the corridor, and located below the sanitary unit, is permitted where the cross-sectional area of the duct does not exceed 0.05 m^2. Ventilation openings, except those under the door, shall be fitted with a grill made of non-combustible material.

3.3.4 Watertight doors need not be insulated.

4 Protection of openings in machinery space boundaries

4.1 Application

4.1.1 The provisions of Article 4 shall apply to machinery spaces of category A and, where the Society considers it desirable, to other machinery spaces.

The provisions of 4.2 apply to ships of all types, except those of 4.2.3 and 4.2.5 which apply to passenger ships.

4.2 Protection of openings in machinery space boundaries

4.2.1

a) The number of skylights, doors, ventilators, openings in funnels to permit exhaust ventilation and other openings to machinery spaces shall be reduced to a minimum consistent with the needs of ventilation and the proper and safe working of the ship.

b) Skylights shall be of steel and shall not contain glass panels.

4.2.2 Means of control shall be provided for closing power operated doors or actuating release mechanisms on doors other than power-operated watertight doors. The controls shall be located outside the space concerned, where they will not be cut off in the event of fire in the space they serve.

4.2.3 The means of control required in 4.2.2 shall be situated at one control position or grouped in as few positions as possible, to the satisfaction of the Society. Such positions shall have safe access from the open deck.

4.2.4 When access to any machinery space of category A is provided at a low level from an adjacent shaft tunnel, there shall be provided in the shaft tunnel, near the watertight door, a light steel fire-screen door operable from each side.

4.2.5 Doors, other than power-operated watertight doors, shall be so arranged that positive closure is assured in case of fire in the space by power-operated closing arrangements or by the provision of self-closing doors capable of closing against an inclination of 3.5° opposing closure, and having a fail-safe hold-back arrangement, provided with a remotely operated release device. Doors for emergency escape trunks need not be fitted with a fail-safe hold-back facility and a remotely operated release device.

4.2.6 Windows shall not be fitted in machinery space boundaries. However, this does not preclude the use of glass in control rooms within the machinery spaces.

5 Protection of cargo space boundaries

5.1 Application

5.1.1 The provisions of 5.2 to 5.4 apply to passenger ships.

5.2 Passenger ships carrying more than 36 passengers

5.2.1 The boundary bulkheads and decks of special category and ro-ro spaces shall be insulated to A-60 class standard. However, where a category (5), (9) or (10) space, as defined in 1.3.3, is on one side of the division, the standard may be reduced to A-0. Where fuel oil tanks are below a special category space, the integrity of the deck between such spaces may be reduced to A-0 standard.

5.3 Passenger ships carrying not more than 36 passengers

5.3.1 The boundary bulkheads of special category spaces shall be insulated as required for category (11) spaces in Table 1.3 and the horizontal boundaries as required for category (11) spaces in Table 1.4.

5.3.2 The boundary bulkheads and decks of closed and open ro-ro spaces shall have a fire integrity as required for category (8) spaces in Table 1.3 and the horizontal boundaries as required for category (8) spaces in Table 1.4.

5.4 Indicators

5.4.1 Indicators shall be provided on the navigation bridge which shall indicate when any fire door leading to or from the special category spaces is closed.

6 Ventilation systems

6.1 Application

6.1.1 The provisions of 6.2 to 6.4 and 6.6 apply to ships of all types.

The provisions of 6.5 apply to passenger ships carrying more than 36 passengers.

6.2 Duct and dampers

6.2.1 Ventilation ducts shall be of non-combustible material. However, short ducts, not generally exceeding 2 m in length and with a free cross-sectional area not exceeding 0.02 m^2, need not be non-combustible, subject to the following conditions:

a) the ducts are made of a material which has low flame spread characteristics

b) the ducts are only used at the end of the ventilation device, and

c) the ducts are not situated less than 600 mm, measured along the duct, from an opening in an A or B class division, including continuous B class ceiling.

Flexible bellows of combustible material may be used for connecting fans to the ducting in the air conditioning room.

Combustible gaskets in flanged ventilation duct connections are not permitted within 600 mm of an opening in an A or B class divisions and in ducts required to be of A class construction.

6.2.2 The following arrangements shall be tested in accordance with the Fire Test Procedures Code:

a) fire dampers, including their relevant means of operation, and

b) duct penetrations through A class divisions. However, the test is not required where steel sleeves are directly joined to ventilation ducts by means of riveted or screwed flanges or by welding.

6.3 Arrangements of ducts

6.3.1 The ventilation systems for machinery spaces of category A, vehicle spaces, ro-ro spaces, galleys, special category spaces and cargo spaces shall, in general, be separated from each other and from the ventilation systems serving other spaces, except that the galley ventilation systems on cargo ships of less than 4000 gross tonnage and in passenger ships carrying not more than 36 passengers need not be completely separated, but may be served by separate ducts from a ventilation unit serving other spaces. In any case, an automatic fire damper shall be fitted in the galley ventilation duct near the ventilation unit. Ducts provided for the ventilation of machinery spaces of category A, galleys, vehicle spaces, ro-ro spaces or special category spaces shall not pass through accommodation spaces, service spaces or control stations unless they comply with the conditions specified in items a) to d) or items e) and f) below:

a) the ducts are constructed of steel having a thickness of at least 3 mm and 5 mm for ducts the widths or diameters of which are up to and including 300 mm and 760 mm and over, respectively, and, in the case of such ducts, the widths or diameters of which are between 300 mm and 760 mm, having a thickness obtained by interpolation

b) the ducts are suitably supported and stiffened

c) the ducts are fitted with automatic fire dampers close to the boundaries penetrated, and

d) the ducts are insulated to A-60 class standard from the machinery spaces, galleys, vehicle spaces, ro-ro spaces or special category spaces to a point at least 5 m beyond each fire damper or

e) the ducts are constructed of steel in accordance with the preceding items a) and b), and

f) the ducts are insulated to A-60 class standard throughout the accommodation spaces, service spaces or control stations, except that penetrations of main zone divisions shall also comply with the requirements of 6.5.7.

6.3.2 Ducts provided for ventilation to accommodation spaces, service spaces or control stations shall not pass through machinery spaces of category A, galleys, vehicle spaces, ro-ro spaces or special category spaces unless they comply with the conditions specified in items a) to c) or items d) and e) below:

a) the ducts, where they pass through a machinery space of category A, galley, vehicle space, ro-ro space or special category space, are constructed of steel in accordance with items a) and b) of 6.3.1

b) automatic fire dampers are fitted close to the boundaries penetrated, and

c) the integrity of the machinery space, galley, vehicle space, ro-ro space or special category space boundaries is maintained at the penetrations,

or

d) the ducts, where they pass through a machinery space of category A, galley, vehicle space, ro-ro space or special category space, are constructed of steel in accordance with items a) and b) of 6.3.1, and

e) the ducts are insulated to A-60 standard within the machinery space, galley, vehicle space, ro-ro space or special category space, except that penetrations of main zone divisions shall also comply with the requirements of 6.5.7.

6.3.3 Balancing openings or ducts between two enclosed spaces are prohibited except for openings as permitted by item a) of 3.2.2 and 3.3.3.

6.4 Details of duct penetrations

6.4.1 Where a thin plated duct with a free cross-sectional area equal to, or less than, 0.02 m^2 passes through A class bulkheads or decks, the opening shall be lined with a steel sheet sleeve having a thickness of at least 3 mm and a length of at least 200 mm, divided preferably into 100 mm on each side of the bulkhead or, in the case of the deck, wholly laid on the lower side of the decks pierced. Where ventilation ducts with a free cross-sectional area exceeding 0.02 m^2 pass through A class bulkheads or decks, the opening shall be lined with a steel sheet sleeve. However, where such ducts are of steel construction and pass through a deck or bulkhead, the ducts and sleeves shall comply with the following:

a) The sleeves shall have a thickness of at least 3 mm and a length of at least 900 mm. When passing through bulkheads, this length shall be divided preferably into 450 mm on each side of the bulkhead. These ducts, or sleeves lining such ducts, shall be provided with fire insulation. The insulation shall have at least the same fire integrity as the bulkhead or deck through which the duct passes.

Equivalent penetration protection may be provided to the satisfaction of the Society, and

b) Ducts with a free cross-sectional area exceeding 0.075 m^2 shall be fitted with fire dampers in addition to the requirements of the preceding item a). The fire damper shall operate automatically, but shall also be capable of being closed manually from both sides of the bulkhead or deck. The damper shall be provided with an indicator which shows whether the damper is open or closed. Fire dampers are not required, however, where ducts pass through spaces surrounded by A class divisions, without serving those spaces, provided those ducts have the same fire integrity as the divisions which they pierce. Fire dampers shall be easily accessible. Where they are placed behind ceilings or linings, these ceilings or linings shall be provided with an inspection door on which a plate reporting the identification number of the fire damper is provided. The fire damper identification number shall also be placed on any remote controls required.

6.4.2 With reference to the requirements of 6.4.1, the following applies:

The term “free cross-sectional area” means, even in the case of a pre-insulated duct, the area calculated on the basis of the inner diameter of the duct.

6.4.3 Ventilation ducts with a free cross-sectional area exceeding 0.02 m^2 passing through B class bulkheads shall be lined with steel sheet sleeves of 900 mm in length, divided preferably into 450 mm on each side of the bulkheads unless the duct is of steel for this length.

6.5 Ventilation systems for passenger ships carrying more than 36 passengers

6.5.1 The ventilation system of a passenger ship carrying more than 36 passengers shall be in compliance with the following additional requirements.

6.5.2 In general, the ventilation fans shall be so disposed that the ducts reaching the various spaces remain within the main vertical zone.

6.5.3 Where ventilation systems penetrate decks, precautions shall be taken, in addition to those relating to the fire integrity of the deck required by 2.1 and item e) of 3.2.1, to reduce the likelihood of smoke and hot gases passing from one ’tweendeck space to another through the system.

In addition to insulation requirements contained in 6.5.4, vertical ducts shall, if necessary, be insulated as required by the appropriate Tab 1.1 and Tab 1.2.

A duct, irrespective of its cross section, serving more than one tweendeck, should be fitted, near the penetration of each deck served, with a fire or smoke damper. Such dampers should close automatically by means of a fusible link or other suitable device, and manually from the deck in which the passage of smoke, due to a fire in the deck immediately below which is served by the same duct, will be avoided. Where, within a main vertical zone, a fan serves more than one tweendeck through separate ducts, each of these dedicated to a single tweendeck, each duct should be provided with a manually operated smoke damper fitted close to the fan.

6.5.4 Except in cargo spaces, ventilation ducts shall be constructed of the following materials:

a) ducts not less than 0.075 m^2 in free cross-sectional area and all vertical ducts serving more than a single ’tweendeck space shall be constructed of steel or other equivalent material

b) ducts less than 0.075 m^2 in free cross-sectional area, other than the vertical ducts referred to in the preceding item a), shall be constructed of non-combustible materials.

Where such ducts penetrate A or B class divisions, due regard shall be given to ensuring the fire integrity of the division, and c) short lengths of duct, not in general exceeding 0.02 m^2 in free cross-sectional area nor 2 m in length, need not be non-combustible provided that all of the following conditions are met:

1) the duct is constructed of a material which has low flame-spread characteristics

2) the duct is used only at the terminal end of the ventilation system, and

3) the duct is not located closer than 600 mm measured along its length to a penetration of an A or B class division, including continuous B class ceilings.

6.5.5 Stairway enclosures shall be ventilated and served by an independent fan and duct system which shall not serve any other spaces in the ventilation systems.

6.5.6 Exhaust ducts shall be provided with hatches for inspection and cleaning. The hatches shall be located near the fire dampers.

6.5.7 Where it is necessary that a ventilation duct passes through a main vertical zone division, a fail-safe automatic closing fire damper shall be fitted adjacent to the division.

The damper shall also be capable of being manually closed from each side of the division. The operating position shall be readily accessible and be marked in red light-reflecting colour. The duct between the division and the damper shall be of steel or other equivalent material and, if necessary, insulated to comply with the requirements of 2.1.1. The damper shall be fitted on at least one side of the division with a visible indicator showing whether the damper is in the open position.

6.6 Exhaust ducts from galley ranges

6.6.1 Requirements for passenger ships carrying more than 36 passengers

Exhaust ducts from galley ranges shall meet the requirements of items e) and f) of 6.3.1 and shall be fitted with:

a) a grease trap readily removable for cleaning unless an alternative approved grease removal system is fitted

b) a fire damper located in the lower end of the duct which is automatically and remotely operated and, in addition, a remotely operated fire damper located in the upper end of the duct

c) a fixed means for extinguishing a fire within the duct

d) remote control arrangements for shutting off the exhaust fans and supply fans, for operating the fire dampers mentioned in item b) and for operating the fire-extinguishing system, which shall be placed in a position close to the entrance to the galley. Where a multibranch system is installed, a remote means located with the above controls shall be provided to close all branches exhausting through the same main duct before an extinguishing medium is released into the system; and

e) suitably located hatches for inspection and cleaning. The requirements given in a) to e) above apply to all exhaust ducts from galley ranges in which grease or fat is likely to accumulate from galley ranges.

With reference to the requirement of item e) above:

- one hatch is to be provided close to the exhaust fan
- in the galley exhaust duct the grease will accumulate more in the lower end. Therefore, hatches are to be fitted also in this part of the duct.

6.6.2 Requirements for passenger ships carrying not more than 36 passengers and cargo ships

Where they pass through accommodation spaces or spaces containing combustible materials, the exhaust ducts from galley ranges shall be constructed of A class divisions. Each exhaust duct shall be fitted with:

a) a grease trap readily removable for cleaning

b) a fire damper located in the lower end of the duct

c) arrangements, operable from within the galley, for shutting off the exhaust fans, and

d) fixed means for extinguishing a fire within the duct.

Section 6 Suppression of Fire: Fire Fighting

1 Water supply systems

1.1 General

1.1.1 Ships shall be provided with fire pumps, fire mains, hydrants and hoses complying with the applicable requirements of this Section.

1.2 Fire mains and hydrants

1.2.1 General

Materials readily rendered ineffective by heat shall not be used for fire mains and hydrants unless adequately protected. The pipes and hydrants shall be so placed that the fire hoses may be easily coupled to them. The arrangement of pipes and hydrants shall be such as to avoid the possibility of freezing. Suitable drainage provisions shall be provided for fire main piping. Isolation valves shall be installed for all open deck fire main branches used for purposes other than fire fighting. In ships where deck cargo may be carried, the positions of the hydrants shall be such that they are always readily accessible and the pipes shall be arranged as far as practicable to avoid risk of damage by such cargo.

1.2.2 Ready availability of water supply

The arrangements for the ready availability of water supply shall be:

a) in passenger ships:

1) of 1000 gross tonnage and upwards such that at least one effective jet of water is immediately available from any hydrant in an interior location and so as to ensure the continuation of the output of water by the automatic starting of one required fire pump,

2) of less than 1000 gross tonnage by automatic start of at least one fire pump or by remote starting from the navigation bridge of at least one fire pump. If the pump starts automatically or if the bottom valve cannot be opened from where the pump is remotely started, the bottom valve shall always be kept open, and

3) if fitted with periodically unattended machinery spaces, the Society shall determine provisions for fixed water fire-extinguishing arrangements for such spaces equivalent to those required for normally attended machinery spaces;

b) in cargo ships:

with a periodically unattended machinery space or when only one person is required on watch, there shall be immediate water delivery from the fire main system at a suitable pressure, either by remote starting of one of the main fire pumps with remote starting from the navigation bridge and fire control station, if any, or permanent pressurization of the fire main system by one of the main fire pumps, except that the Society may waive this requirement for cargo ships of less than 1600 gross tonnage if the fire pump starting arrangement in the machinery space is in an easily accessible position.

1.2.3 Diameter of fire mains

The diameter of the fire main and water service pipes shall be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously, except that in the case of cargo ships the diameter need only be sufficient for the discharge of 140 m^3/hour.

1.2.4 Isolating valves and relief valves

a) Isolating valves to separate the section of the fire main within the machinery space containing the main fire pump or pumps from the rest of the fire main shall be fitted in an easily accessible and tenable position outside the machinery spaces. The fire main shall be so arranged that when the isolating valves are shut all the hydrants on the ship, except those in the machinery space referred to above, can be supplied with water by another fire pump or an emergency fire pump. The emergency fire pump, its seawater inlet, and suction and delivery pipes and isolating valves shall be located outside the machinery space. If this arrangement cannot be made, the sea-chest may be fitted in the machinery space if the valve is remotely controlled from a position in the same compartment as the emergency fire pump and the suction pipe is as short as practicable. Short lengths of suction or discharge piping may penetrate the machinery space, provided they are enclosed in a substantial steel casing or are insulated to A-60 class standards.

The pipes shall have substantial wall thickness, but in no case less than 11 mm, and shall be welded except for the flanged connection to the sea inlet valve.

b) A valve shall be fitted to serve each fire hydrant so that any fire hose may be removed while the fire pumps are in operation.

c) Relief valves shall be provided in conjunction with fire pumps if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves shall be so placed and adjusted as to prevent excessive pressure in any part of the fire main system.

d) In tankers, isolation valves shall be fitted in the fire main at the poop front in a protected position and on the tank deck at intervals of not more than 40 m to preserve the integrity of the fire main system in case of fire or explosion.

1.2.5 Number and position of hydrants

a) The number and position of hydrants shall be such that at least two jets of water not emanating from the same hydrant, one of which shall be from a single length of hose, may reach any part of the ship normally accessible to the passengers or crew while the ship is being navigated and any part of any cargo space when empty, any ro-ro space or any vehicle space, in which latter case the two jets shall reach any part of the space, each from a single length of hose. Furthermore, such hydrants shall be positioned near the accesses to the protected spaces.

At least two hydrants are to be provided in machinery spaces of category A.

b) In addition to the requirements in item a) above, passenger ships shall comply with the following:

1) in the accommodation, service and machinery spaces, the number and position of hydrants shall be such that the requirements of item a) above may be complied with when all watertight doors and all doors in main vertical zone bulkheads are closed, and

2) where access is provided to a machinery space of category A at a low level from an adjacent shaft tunnel, two hydrants shall be provided external to, but near the entrance to, that machinery space. Where such access is provided from other spaces, in one of those spaces two hydrants shall be provided near the entrance to the machinery space of category A. Such provision need not be made where the tunnel or adjacent spaces are not part of the escape route.

1.2.6 Pressure at hydrants

With the two pumps simultaneously delivering water through the nozzles specified in 1.2.3, with the quantity of water as specified in 1.4.3, through any adjacent hydrants, the following minimum pressures shall be maintained at all hydrants:

a) for passenger ships:

- 4000 gross tonnage and upwards .... 0.40 N/mm^2
- less than 4000 gross tonnage .... 0.30 N/mm^2

b) for cargo ships:

- 6000 gross tonnage and upwards .... 0.27 N/mm^2
- less than 6000 gross tonnage .... 0.25 N/mm^2

and

c) the maximum pressure at any hydrant shall not exceed that at which the effective control of a fire hose can be demonstrated.

1.2.7 International shore connection

Ships of 500 gross tonnage and upwards shall be provided with at least one international shore connection complying with Sec 13. Facilities shall be available enabling such a connection to be used on either side of the ship.

1.3 Fire pumps

1.3.1 Pumps accepted as fire pumps

Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil and that, if they are subject to occasional duty for the transfer or pumping of oil fuel, suitable change-over arrangements are fitted.

The emergency fire pump mentioned in 1.3.3 may also be used for other suitable purposes subject to approval by the Society in each case.

1.3.2 Number of fire pumps

Ships shall be provided with independently driven fire pumps as follows:

a) in passenger ships of:

- 4000 gross tonnage and upwards .... at least 3
- less than 4000 gross tonnage .... at least 2

b) in cargo ships of:

- 1000 gross tonnage and upwards .... at least 2
- less than 1000 gross tonnage .... at least 2 power driven pumps, one of which shall be independently driven.

1.3.3 Arrangement of fire pumps and fire mains

a) Fire pumps

The arrangement of sea connections, fire pumps and their sources of power shall be as to ensure that:

1) in passenger ships of

- 1000 gross tonnage and upwards, in the event of a fire in any one compartment, all the fire pumps will not be put out of action
- less than 1000 gross tonnage, if a fire in any one compartment could put all the pumps out of action, there shall be an alternative means consisting of an emergency fire pump complying with Sec 13, 11.1.1 with its source of power and sea connection located outside the space where the main fire pumps or their sources of power are located.

2) in cargo ships of 500 gross tonnage and upwards, • unless the two main fire pumps and the fuel supply or source of power for each pump are situated within compartments separated at least by an A-0 class division, so that a fire in any one compartment will not render both fire pumps inoperable, a fixed independent power perated emergency fire pump complying with the following requirements and those of Sec 13, 11 is to be fitted (for cargo ships of less than 2000 gross tonnage only, Sec 13, 11.1.1 applies). An arrangement in which one main fire pump is located in a steel compartment having more than one bulkhead and/or deck adjacent to the compartment containing the other main fire pump will also require an emergency fire pump

- Where a power operated emergency fire pump is fitted, its fuel or power supply is to be so arranged that it will not readily be affected by a fire in the compartment containing the main fire pumps.

b) Requirements for the space containing the emergency fire pump in cargo ships

1) Location of the space

The space containing the fire pump shall not be contiguous to the boundaries of machinery spaces of category A or those spaces containing main fire pumps. Where this is not practicable, the common bulkhead between the two spaces shall be insulated to a standard of structural fire protection equivalent to that required for a control station in Sec 5, 1.4.3.

2) Access to the emergency fire pump No direct access shall be permitted between the machinery space and the space containing the emergency fire pump and its source of power. When this is impracticable, the Society may

accept an arrangement where the access is by means of an airlock with the door of the machinery space being of A-60 class standard and the other door being at least steel, both reasonably gastight, self-closing and without any hold-back arrangements. Alternatively, the access may be through a watertight door capable of being operated from a space remote from the machinery space and the space containing the emergency fire pump and unlikely to be cut off in the event of fire in those spaces. In such cases, a second means of access to the space containing the emergency fire pump and its source of power shall be provided.

When a single access to the emergency fire pump room is through another space adjoining a machinery space of category A or the spaces containing the main fire pumps, an A-60 class boundary is required between such other space and the machinery space of category A or the spaces containing the main fire pumps.

3) Ventilation of the emergency fire pump space Ventilation arrangements to the space containing the independent source of power for the emergency fire pump shall be such as to preclude, as far as practicable, the possibility of smoke from a machinery space fire entering or being drawn into that space.

If the space is mechanically ventilated the power is to be supplied by the emergency source.

4) Illumination of the space. The room where the emergency fire pump prime mover is located is to be illuminated from the emergency source of supply and is to be well ventilated.

c) Additional pumps for cargo ships In addition, in cargo ships where other pumps, such as general service, bilge and ballast, etc., are fitted in a machinery space, arrangements shall be made to ensure that at least one of these pumps, having the capacity and pressure required by 1.3.4 item b) and by 1.2.6 item b), is capable of providing water to the fire main.

1.3.4 Capacity of fire pumps

a) Total capacity of required fire pumps

The required fire pumps shall be capable of delivering for fire-fighting purposes a quantity of water, at the pressure specified in 1.2.6, as follows:

1) pumps in passenger ships: the quantity of water is not less than two thirds of the quantity required to be dealt with by the bilge pumps when employed for bilge pumping, and

2) pumps in cargo ships, other than any emergency pump: the quantity of water is not less than four thirds of the quantity required in Sec 10 to be dealt with by each of the independent bilge pumps in a passenger ship of the same dimension when employed in bilge pumping, provided that in no cargo ship need the total required capacity of the fire pumps exceed 180 m^3/hour.

b) Capacity of each fire pump

Each of the required fire pumps (other than any emergency pump required in 1.3.3 a) for cargo ships) shall have a capacity not less than 80% of the total required capacity divided by the minimum number of required fire pumps, but in any case not less than 25 m^3/hour, and each such pump shall in any event be capable of delivering at least the two required jets of water. These fire pumps shall be capable of supplying the fire main system under the required conditions. Where more pumps than the minimum of required pumps are installed, such additional pumps shall have a capacity of at least 25 m^3/h and shall be capable of delivering at least the two jets of water required in 1.2.5 a).

1.4 Fire hoses and nozzles

1.4.1 General specifications

a) Fire hoses shall be of non-perishable material approved by the Society and shall be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Each hose shall be provided with a nozzle and the necessary couplings. Hoses specified in this Section as "fire hoses" shall, together with any necessary fittings and tools, be kept ready for use in conspicuous positions near the water service hydrants or connections. Additionally, in interior locations in passenger ships carrying more than 36 passengers, fire hoses shall be connected to the hydrants at all times. Fire hoses shall have a length of at least 10 m, but not more than:

- 15 m in machinery spaces
- 20 m in other spaces and open decks, and
- 25 m for open decks on ships with a maximum breadth in excess of 30 m.

b) Unless one hose and nozzle is provided for each hydrant in the ship, there shall be complete interchangeability of hose couplings and nozzles.

1.4.2 Number and diameter of fire hoses

a) Ships shall be provided with fire hoses, the number and diameter of which shall be to the satisfaction of the Society.

b) In passenger ships, there shall be at least one fire hose for each of the hydrants required by 1.2.5 and these hoses shall be used only for the purposes of extinguishing fires or testing the fire-extinguishing apparatus at fire drills and surveys.

c) In cargo ships:

1) of 1000 gross tonnage and upwards, the number of fire hoses to be provided shall be one for each 30 m length of the ship and one spare, but in no case less than five in all. This number does not include any hoses required in any engine-room or boiler room.

The Society may increase the number of hoses required so as to ensure that hoses in sufficient number are available and accessible at all times, having regard to the type of ship and the nature of trade in which the ship is employed. Ships carrying dangerous goods in accordance with Sec 11 shall be provided with three hoses and nozzles, in addition to those required above.

Hydrants in machinery spaces of category A shall be provided with fire hoses, and 2) of less than 1000 gross tonnage, the number of fire hoses to be provided shall be calculated in accordance with the provisions of item 1) above. However the number of hoses shall in no case be less than three.

1.4.3 Size and type of nozzles

a) For the purposes of this Section, standard nozzle sizes shall be 12 mm, 16 mm and 19 mm or as near thereto as possible. Larger diameter nozzles may be permitted at the discretion of the Society.

b) For accommodation and service spaces, a nozzle size greater than 12 mm need not be used.

c) For machinery spaces and exterior locations, the nozzle size shall be such as to obtain the maximum discharge possible from two jets at the pressure mentioned in 1.2.6 from the smallest pump, provided that a nozzle size greater than 19 mm need not be used.

d) Nozzles shall be of an approved dual-purpose type (i.e. spray/jet type) incorporating a shut-off.

2 Portable fire extinguishers

2.1 Type and design

2.1.1 Portable fire extinguishers shall comply with the requirements of Sec 13.

2.2 Arrangement of fire extinguishers

2.2.1 Accommodation spaces, service spaces and control stations shall be provided with portable fire extinguishers of appropriate types and in sufficient number to the satisfaction of the Society. Ships of 1000 gross tonnage and upwards shall carry at least five portable fire extinguishers.

The number and the type of portable fire extinguishers required for the above-mentioned spaces are to be as follows:

- in accommodation and service spaces of passenger ships: one foam extinguisher or equivalent, for each group of adjacent spaces with easy access between them having total deck area not exceeding 200 m^2
- in accommodation spaces of cargo ships of 1000 gross tonnage and upwards: at least five foam extinguishers or equivalent, but not less than one for each 'tweendeck
- in accommodation spaces of cargo ships of less than 1000 gross tonnage: at least two foam extinguishers or equivalent, but not less than one for each 'tweendeck
- in the proximity of any electric switchboard or section board having a power of 20 kW and upwards: at least one CO_2 or powder extinguisher
- in any service space where deep fat cooking equipment is installed: at least one foam extinguisher or equivalent

- in the proximity of any paint or flammable product locker: at least one foam extinguisher or equivalent
- on the navigating bridge: one CO_2 extinguisher or equivalent.

2.2.2 One of the portable fire extinguishers intended for use in any space shall be stowed near the entrance to that space.

3 Fixed fire-extinguishing systems

3.1 Types of fixed fire-extinguishing systems

3.1.1 A fixed fire extinguishing system required by article 4 may be any of the following systems:

a) a fixed gas fire-extinguishing system complying with the provisions of Sec 13

b) a fixed high-expansion foam fire-extinguishing system complying with the provisions of Sec 13, and

c) a fixed pressure water-spraying fire-extinguishing system complying with the provisions of Sec 13.

3.1.2 Where a fixed fire-extinguishing system not required by this Section is installed, it shall meet the relevant requirements of this Section.

3.1.3 Fire-extinguishing systems using Halon 1211, 1301, and 2402 and perfluorocarbons shall be prohibited.

3.1.4 In general, the Society shall not permit the use of steam as a fire-extinguishing medium in fixed fire-extinguishing systems.

3.2 Closing appliances for fixed gas fire extinguishing systems

3.2.1 Where a fixed gas fire-extinguishing system is used, openings which may admit air to, or allow gas to escape from, a protected space shall be capable of being closed from outside the protected space.

3.3 Storage rooms of fire-extinguishing medium

3.3.1 When the fire-extinguishing medium is stored outside a protected space, it shall be stored in a room which is located behind the forward collision bulkhead, and is used for no other purposes. Any entrance to such a storage room shall preferably be from the open deck and shall be independent of the protected space. If the storage space is located below deck, it shall be located no more than one deck below the open deck and shall be directly accessible by a stairway or ladder from the open deck. Spaces which are located below deck or spaces where access from the open deck is not provided shall be fitted with a mechanical ventilation system designed to take exhaust air from the bottom of the space and shall be sized to provide at least 6 air changes per hour. Access doors shall open outwards, and bulkheads and decks, including doors and other means of closing any opening therein, which form the boundaries between such rooms and adjacent enclosed spaces, shall be gastight. For the purpose of the application of Sec 5, Table 1.1 to Table 1.8, such storage rooms shall be treated as fire control stations.

3.4 Water pumps for other fire-extinguishing systems

3.4.1 Pumps, other than those serving the fire main, required for the provision of water for fire-extinguishing systems required by the present Section, their sources of power and their controls shall be installed outside the space or spaces protected by such systems and shall be so arranged that a fire in the space or spaces protected will not put any such system out of action.

4 Fire-extinguishing arrangements in machinery spaces

4.1 Machinery spaces arrangement

4.1.1 General

a) The arrangement of machinery spaces is to be such that safe storage and handling of flammable liquids is ensured.

b) All spaces where oil-consuming installations, settling tanks or daily service fuel tanks are located are to be easily accessible and well ventilated.

c) Where leakage of flammable liquids may occur during normal service or routine maintenance work, special arrangement is to be made to prevent these fluids from reaching other parts of the machinery where danger of ignition may arise.

d) Materials used in machinery spaces are not normally to have properties increasing the fire potential of these rooms. Neither combustible nor oil-absorbing materials are to be used as flooring, bulkhead lining, ceiling or deck in the control room, machinery spaces, shaft tunnel or rooms where oil tanks are located. Where penetration of oil products is possible, the surface of the insulation is to be impervious to oil or oil vapours.

4.1.2 Segregation of fuel oil purifiers and other systems for preparing flammable liquids

a) The system (such as purifiers) for preparing flammable liquids for use in boilers and machinery, and separate oil systems with working pressure above 1.5 MPa and which are not part of the main engines, auxiliary engines or boilers etc., are subject to the following additional requirements.

b) The main components in the systems as per a) are to be placed in a separate room, enclosed by steel bulkheads extending from deck to deck and provided with selfclosing steel doors.

c) Rooms in which flammable liquids are handled as specified in a) above are to be provided with:

- independent mechanical ventilation or ventilation arrangements which can be isolated from the machinery space ventilation
- a fire detecting system
- a fixed fire-extinguishing installation. The extinguishing installation is to be capable of being activated from outside the room. The extinguishing system is to be separated from the room, but may be a part of the main fire-extinguishing system for the machinery space. Closing of ventilation openings is to be effected from a position close to where the extinguishing system is activated.

d) Where the size of the engine room makes it impracticable to locate the main components of such systems in a separate space, special consideration will be given by the Society with regard to the location, containment of possible leakages and shielding of the components, and to ventilation.

A local fixed fire-extinguishing system is to be provided, capable of being activated automatically or activated manually from the machinery control position or from another suitable location. If automatic release is provided, additional manual release is to be arranged.

4.2 Machinery spaces containing oil-fired boilers or oil fuel units

4.2.1 Fixed fire-extinguishing systems

Machinery spaces of category A containing oil fired boilers or oil fuel units shall be provided with any one of the fixed fire-extinguishing systems in 3.1.

In each case, if the engine-room and boiler room are not entirely separate, or if fuel oil can drain from the boiler room into the engine-room, the combined engine and boiler rooms shall be considered as one compartment.

4.2.2 Additional fire-extinguishing arrangements

a) There shall be in each boiler room or at an entrance outside of the boiler room at least one portable foam applicator unit complying with the provisions of Sec 13.

b) There shall be at least two portable foam extinguishers or equivalent in each firing space in each boiler room and in each space in which a part of the oil fuel installation is situated. There shall be not less than one approved foam-type extinguisher of at least 135 l capacity or equivalent in each boiler room. These extinguishers shall be provided with hoses on reels suitable for reaching any part of the boiler room. In the case of domestic boilers of less than 175 kW an approved foamtype extinguisher of at least 135 l capacity is not required.

In the case of domestic boilers of less than 175 kW in cargo ships, the Society may consider relaxing the requirements of this item b) to the provision of two portable fire extinguishers.

In the proximity of any electric switchboard or section board having a power of 20 kW and upwards at least one CO_2 or powder extinguisher is to be fitted.

c) In each firing space there shall be a receptacle containing at least 0.1 m^3 sand, sawdust impregnated with soda, or other approved dry material, along with a suitable shovel for spreading the material. An approved portable extinguisher may be substituted as an alternative.

4.3 Machinery spaces containing internal combustion machinery

4.3.1 Fixed fire-extinguishing systems

Machinery spaces of category A containing internal combustion machinery shall be provided with one of the fixed fire-extinguishing systems required in 3.1.

4.3.2 Additional fire-extinguishing arrangements

a) There shall be at least one portable foam applicator unit complying with the provisions of Sec 13.

b) There shall be in each such space approved foam-type fire extinguishers, each of at least 45 l capacity or equivalent, sufficient in number to enable foam or its equivalent to be directed onto any part of the fuel and lubricating oil pressure systems, gearing and other fire hazards. In addition, there shall be provided a sufficient number of portable foam extinguishers or equivalent which shall be so located that no point in the space is more than 10 m walking distance from an extinguisher and that there are at least two such extinguishers in each such space. For smaller spaces of cargo ships, the Society may consider relaxing this requirement.

c) In the case of machinery spaces containing both boilers and internal combustion engines, 4.2 and 4.3 apply, with the exception that one of the foam fire extinguishers of at least 45 l capacity or equivalent may be omitted provided that the 136 l extinguisher can efficiently and readily protect the area covered by the 45 l extinguishers.

d) There shall be at least one CO_2 or powder extinguisher in the proximity of any electric switchboard or section board having a power of 20 kW and upwards.

4.4 Machinery spaces containing steam turbines or enclosed steam engines

4.4.1 Fixed fire-extinguishing systems

In spaces containing steam turbines or enclosed steam engines used for main propulsion or other purposes having in the aggregate a total output of not less than 375 kW, one of the fire-extinguishing systems specified in 3.1 shall be provided if such spaces are periodically unattended.

4.4.2 Additional fire-extinguishing arrangements

a) There shall be approved foam fire extinguishers, each of at least 45 l capacity or equivalent, sufficient in number to enable foam or its equivalent to be directed on to any part of the pressure lubrication system, on to any part of the casings enclosing pressure-lubricated parts of the turbines, engines or associated gearing, and any other fire hazards. However, such extinguishers shall not be required if protection, at least equivalent to that required by this item, is provided in such spaces by a fixed fire-extinguishing system fitted in compliance with 3.1.

b) There shall be a sufficient number of portable foam extinguishers or equivalent which shall be so located that no point in the space is more than 10 m walking distance from an extinguisher and that there are at least two such extinguishers in each such space, except that such extinguishers shall not be required in addition to any provided in compliance with item b) of 4.2.2.

c) There shall be at least one CO_2 or powder extinguisher in the proximity of any electric switchboard or section board having a power of 20 kW and upwards.

4.5 Other machinery spaces

4.5.1 Where, in the opinion of the Society, a fire hazard exists in any machinery space for which no specific provisions for fire-extinguishing appliances are prescribed in 4.2, 4.3 and 4.4, there shall be provided in, or adjacent to, that space such a number of approved portable fire extinguishers or other means of fire extinction as the Society may deem sufficient.

4.6 Additional requirements for passenger ships

4.6.1 In passenger ships carrying more than 36 passengers, each machinery space of category A shall be provided with at least two suitable water fog applicators, complying with Sec 13.

4.7 Fixed local application fire-extinguishing systems

4.7.1 The present sub-article shall apply to passenger ships of 500 gross tonnage and above and cargo ships of 2000 gross tonnage and above.

4.7.2 Machinery spaces of category A above 500 m3 in volume shall, in addition to the fixed fire-extinguishing system required in 4.2.1, be protected by an approved type of fixed water-based or equivalent local application fire-extinguishing system. In the case of periodically unattended machinery spaces, the fire-extinguishing system shall have both automatic and manual release capabilities. In the case of continuously manned machinery spaces, the fire-extinguishing system is only required to have a manual release capability.

4.7.3 Fixed local application fire-extinguishing systems are to protect areas such as the following without the necessity of engine shutdown, personnel evacuation, or sealing of the spaces:

a) the fire hazard portions of internal combustion machinery used for the ship's main propulsion and power generation

b) boiler fronts

c) the fire hazard portions of incinerators, and

d) purifiers for heated fuel oil.

4.7.4 Activation of any local application system shall give a visual and distinct audible alarm in the protected space and at continuously manned stations. The alarm shall indicate the specific system activated. The system alarm requirements described within this requirement are in addition to, and not a substitute for, the detection and fire alarm system required elsewhere in this Section.

5 Fire-extinguishing arrangements in control stations, accommodation and service spaces

5.1 Sprinkler and water spray systems in passenger ships

5.1.1 Passenger ships carrying more than 36 passengers shall be equipped with an automatic sprinkler, fire detection and fire alarm system of an approved type complying with the requirements of Sec 13 in all control stations, accommodation and service spaces, including corridors and stairways. Alternatively, control stations, where water may cause damage to essential equipment, may be fitted with an approved fixed fire-extinguishing system of another type. Spaces having little or no fire risk such as voids, public toilets, carbon dioxide rooms and similar spaces need not be fitted with an automatic sprinkler system.

5.1.2 In passenger ships carrying not more than 36 passengers, when a fixed smoke detection and fire alarm system complying with the provisions of Sec 13 is provided only in corridors, stairways and escape routes within accommodation spaces, an automatic sprinkler system shall be installed in accordance with Sec 3, 4.4.1, item b).

5.1.3 A fixed pressure water-spraying fire-extinguishing system complying with the provisions of the Fire Safety Systems Code shall be installed on cabin balconies to which Sec 2, 2.2.4 applies, when furniture and furnishings on such balconies are not as defined in Sec 1, 3.33.1, items a), b), c), f) and g).

5.2 Sprinkler systems for cargo ships

5.2.1 In cargo ships in which method IIC specified in a)2) of Sec 5, 1.4.1 is adopted, an automatic sprinkler, fire detection and fire alarm system shall be fitted in accordance with the requirements of Sec 3, 4.6.1, item b).

5.3 Spaces containing flammable liquid

5.3.1 Paint lockers shall be protected by:

a) a carbon dioxide system, designed to give a minimum volume of free gas equal to 40% of the gross volume of the protected space

b) a dry powder system, designed for at least 0.5 kg powder/ m^3

c) a water spraying or sprinkler system, designed for 5 l/m^2 min. Water spraying systems may be connected to the fire main of the ship, or

d) a system providing equivalent protection, as determined by the Society.

In all cases, the system shall be operable from outside the protected space.

5.3.2 Flammable liquid lockers shall be protected by an appropriate fire-extinguishing arrangement approved by the Society.

5.3.3 For lockers of a deck area of less than 4 m^2, which do not give access to accommodation spaces, a portable carbon dioxide fire extinguisher sized to provide a minimum volume of free gas equal to 40% of the gross volume of the space may be accepted in lieu of a fixed system. A discharge port shall be arranged in the locker to allow the discharge of the extinguisher without having to enter into the protected space. The required portable fire extinguisher shall be stowed adjacent to the port. Alternatively, a port or hose connection may be provided to facilitate the use of fire main water.

5.4 Deep-fat cooking equipment

5.4.1 Deep-fat cooking equipment shall be fitted with the following:

a) an automatic or manual fire-extinguishing system tested to an international standard

b) a primary and backup thermostat with an alarm to alert the operator in the event of failure of either thermostat

c) arrangements for automatically shutting off the electrical power upon activation of the fire-extinguishing system

d) an alarm for indicating operation of the fire-extinguishing system in the galley where the equipment is installed, and

e) controls for manual operation of the fire-extinguishing system which are clearly labeled for ready use by the crew.

6 Fire-extinguishing arrangements in cargo spaces

6.1 Fixed gas fire-extinguishing systems for general cargo

6.1.1 Except as provided for in 6.2, the cargo spaces of passenger ships of 1000 gross tonnage and upwards shall be protected by a fixed carbon dioxide or inert gas fire-extinguishing system complying with the provisions of Sec 13 or by a fixed high-expansion foam fire-extinguishing system which gives equivalent protection.

6.1.2 Where it is shown to the satisfaction of the Society that a passenger ship is engaged on voyages of such short duration that it would be unreasonable to apply the requirements of 6.1.1 and also in ships of less than 1000 gross tonnage, the arrangements in cargo spaces shall be to the satisfaction of the Society, provided that the ship is fitted with steel hatch covers and effective means of closing all ventilators and other openings leading to the cargo spaces.

6.1.3 Except for ro-ro and vehicle spaces (see Sec 12), cargo spaces on cargo ships of 2000 gross tonnage and upwards shall be protected by a fixed carbon dioxide or inert gas fire-extinguishing system complying with the provisions of Sec 13, or by a fire-extinguishing system which gives equivalent protection.

6.1.4 The Society may exempt from the requirements of 6.1.3 and 6.2 cargo spaces of any cargo ship if constructed, and solely intended, for the carriage of ore, coal, grain, unseasoned timber, non-combustible cargoes or cargoes which, in the opinion of the Society, constitute a low fire risk. Such exemptions may be granted only if the ship is fitted with steel hatch covers and effective means of closing all ventilators and other openings leading to the cargo spaces. When such exemptions are granted, this will be reported on the Certificate of Classification.

6.2 Fixed gas fire-extinguishing systems for dangerous goods

6.2.1 A ship engaged in the carriage of dangerous goods in any cargo spaces shall be provided with a fixed carbon dioxide or inert gas fire-extinguishing system complying with the provisions of Sec 13 or with a fire-extinguishing system which, in the opinion of the Society, gives equivalent protection for the cargoes carried.

Section 7 Suppression of Fire: Structural Integrity

1 Application

1.1 General

1.1.1 The provisions of sub-sections 2 to 5 apply to ships of all types and those of sub-section 6 apply to tankers.

2 Material of hull, superstructures, structural bulkheads, decks and deckhouses

2.1 General

2.1.1 The hull, superstructures, structural bulkheads, decks and deckhouses shall be constructed of steel or other equivalent material. For the purpose of applying the definition of steel or other equivalent material as given in Sec 1, 3.36.1, the "applicable fire exposure" shall be according to the integrity and insulation standards given in Sec 5, Table 1.1 to Table 1.4. For example, where divisions such as decks or sides and ends of deckhouses are permitted to have B-0 fire integrity, the "applicable fire exposure" shall be half an hour.

3 Structure of aluminium alloy

3.1 General

3.1.1 Unless otherwise specified in 2.1.1, in cases where any part of the structure is of aluminium alloy, the following shall apply:

a) The insulation of aluminium alloy components of A or B class divisions, except structure which, in the opinion of the Society, is non-load-bearing, shall be such that the temperature of the structural core does not rise more than 200°C above the ambient temperature at any time during the applicable fire exposure to the standard fire test, and

b) Special attention shall be given to the insulation of aluminium alloy components of columns, stanchions and other structural members required to support lifeboat and liferaft stowage, launching and embarkation areas, and A and B class divisions to ensure:

1) that for such members supporting lifeboat and liferaft areas and A class divisions, the temperature rise limitation specified in the preceding item a) shall apply at the end of one hour, and

2) that for such members required to support B class divisions, the temperature rise limitation specified in the preceding item a) shall apply at the end of half an hour.

4 Machinery spaces of category A

4.1 Crowns and casings

4.1.1 Crowns and casings of machinery spaces of category A shall be of steel construction and shall be insulated as required by Sec 5, Table 1.5 and Table 1.7, as appropriate.

4.2 Floor plating

4.2.1 The floor plating of normal passageways in machinery spaces of category A shall be made of steel.

5 Materials of overboard fittings

5.1 General

5.1.1 Materials readily rendered ineffective by heat shall not be used for overboard scuppers, sanitary discharges, and other outlets which are close to the waterline and where the failure of the material in the event of fire would give rise to danger of flooding.

6 Protection of cargo tank structure against pressure or vacuum

6.1.1 The cargo tank structure should be protected against pressure or vacuum as per relevant requirements (See Part 5, Ch. 7).

Section 8 Escape

1 Notification of crew and passengers

1.1 Application

1.1.1 The provisions of 1.2 apply to ships of all types and those of 1.3 and 1.4 apply to passenger ships.

1.2 General emergency alarm system

1.2.1 A general emergency alarm system required in shall be used for notifying crew and passengers of a fire.

1.3 Special alarm to summon the crew

1.3.1 A special alarm, operated from the navigating bridge or fire control station, shall be fitted to summon the crew.

This alarm may be part of the ship's general alarm system but it shall be capable of being sounded independently of the alarm to the passenger spaces.

1.4 Public address systems

1.4.1 A public address system or other effective means of communication complying with the requirements shall be available throughout the accommodation and service spaces and control stations and open decks.

2 Means of escape

2.1 General requirements

2.1.1 Unless expressly provided otherwise in this Article, at least two widely separated and ready means of escape shall be provided from all spaces or groups of spaces.

2.1.2 Lifts shall not be considered as forming one of the means of escape as required by this Article.

2.2 Means of escape from control stations, accommodation spaces and service spaces

2.2.1 Application

The provisions of 2.2.2 apply to ships of all types, those of 2.2.3 apply to passenger ships and those of 2.2.4 apply to cargo ships.

2.2.2 General requirements

a) Stairways and ladders shall be so arranged as to provide ready means of escape to the lifeboat and liferaft embarkation deck from passenger and crew accommodation spaces and from spaces in which the crew is normally employed, other than machinery spaces.

b) Unless expressly provided otherwise in this Article, a corridor, lobby, or part of a corridor from which there is only one route of escape shall be prohibited. Dead-end corridors used in service areas which are necessary for the practical utility of the ship, such as fuel oil stations and athwartship supply corridors, shall be permitted, provided such dead-end corridors are separated from crew accommodation areas and are inaccessible from passenger accommodation areas. Also, a part of a corridor that has a depth not exceeding its width is considered a recess or local extension and is permitted.

c) All stairways in accommodation and service spaces and control stations shall be of steel frame construction except where the Society sanctions the use of other equivalent material.

d) If a radiotelegraph station has no direct access to the open deck, two means of escape from, or access to, the station shall be provided, one of which may be a porthole or window of sufficient size or other means to the satisfaction of the Society.

e) Doors in escape routes shall, in general, open in way of the direction of escape, except that:

1) individual cabin doors may open into the cabins in order to avoid injury to persons in the corridor when the door is opened, and

2) doors in vertical emergency escape trunks may open out of the trunk in order to permit the trunk to be used both for escape and for access.

2.2.3 Means of escape in passenger ships

a) Escape from spaces below the bulkhead deck

1) Below the bulkhead deck, two means of escape, at least one of which shall be independent of watertight doors, shall be provided from each watertight compartment or similarly restricted space or group of spaces. Exceptionally, the Society may dispense with one of the means of escape for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors.

2) Where the Society has granted dispensation under the provisions of 1) above, this sole means of escape shall provide safe escape. However, stairways shall not be less than 800 mm in clear width with handrails on both sides.

b) Escape from spaces above the bulkhead deck Above the bulkhead deck there shall be at least two means of escape from each main vertical zone or similarly restricted space or group of spaces, at least one of which shall give access to a stairway forming a vertical escape.

c) Direct access to stairway enclosures

Stairway enclosures in accommodation and service spaces shall have direct access from the corridors and be of a sufficient area to prevent congestion, having in view the number of persons likely to use them in an emergency. Within the perimeter of such stairway enclosures, only public toilets, lockers of non-combustible material providing storage for non-hazardous safety equipment and open information counters are permitted.

Only public spaces, corridors, lifts, public toilets, special category spaces and open ro-ro spaces to which any passengers carried can have access, other escape stairways required by the following item d) and external areas are permitted to have direct access to these stairway enclosures. Small corridors or lobbies used to separate an enclosed stairway from galleys or main laundries may have direct access to the stairway provided they have a minimum deck area of 4.5 m^2, a width of no less than 900 mm and contain a fire hose station.

d) Details of means of escape

1) At least one of the means of escape required by the preceding items a) 1) and b) shall consist of a readily accessible enclosed stairway, which shall provide continuous fire shelter from the level of its origin to the appropriate lifeboat and liferaft embarkation decks, or to the uppermost weather deck if the embarkation deck does not extend to the main vertical zone being considered. In the latter case, direct access to the embarkation deck by way of external open stairways and passageways shall be provided and shall have emergency lighting in accordance with Sec 3 and slip-free surfaces underfoot.

   Boundaries facing external open stairways and passageways forming part of an escape route and boundaries in such a position that their failure during a fire would impede escape to the embarkation deck shall have fire integrity, including insulation values, in accordance with Sec 5, Table 1.1 to Table 1.4, as appropriate.

2) Protection of access from the stairway enclosures to the lifeboat and liferaft embarkation areas shall be provided either directly or through protected internal routes which have fire integrity and insulation values for stairway enclosures as determined by Sec 5, Table 1.1 to Table 1.4, as appropriate.

3) Stairways serving only a space and a balcony in that space shall not be considered as forming one of the required means of escape.

4) Each level within an atrium shall have two means of escape, one of which shall give direct access to an enclosed vertical means of escape meeting the requirements of 1) above.

The same requirement applies in general to public spaces spanning two decks.

5) The widths, number and continuity of escapes shall be in accordance with the requirements in Sec 13.

e) Marking of escape routes

1) In addition to the emergency lighting required by the rules, the means of escape, including stairways and exits, shall be marked by lighting or photoluminescent strip indicators placed not more than 300 mm above the deck at all points of the escape route, including angles and intersections. The marking must enable passengers to identify the routes of escape and readily identify the escape exits. If electric illumination is used, it shall be supplied by the emergency source of power and it shall be so arranged that the failure of any single light or cut in a lighting strip will not result in the marking being ineffective. Additionally, escape route signs and fire equipment location markings shall be of photoluminescent material or marked by lighting. The Society shall ensure that such lighting or photoluminescent equipment has been evaluated, tested and applied in accordance with Sec 13.

2) In passenger ships carrying more than 36 passengers, the requirements of item 1) above shall also apply to the crew accommodation areas.

f) Normally locked doors that form part of an escape route Cabin and stateroom doors shall not require keys to unlock them from inside the room. Neither shall there be any doors along any designated escape route which require keys to unlock them when moving in the direction of escape.

Escape doors from public spaces that are normally latched shall be fitted with a means of quick release. Such means shall consist of a door-latching mechanism incorporating a device that releases the latch upon the application of a force in the direction of escape flow. Quick release mechanisms shall be designed and installed to the satisfaction of the Society and, in particular:

1) consist of bars or panels, the actuating portion of which extends across at least one half of the width of the door leaf, at least 760 mm and not more than 1120 mm above the deck

2) cause the latch to release when a force not exceeding 67 N is applied, and

3) not be equipped with any locking device, set screw or other arrangement that prevents the release of the latch when pressure is applied to the releasing device.

2.2.4 Means of escape in cargo ships

a) General

At all levels of accommodation there shall be provided at least two widely separated means of escape from each restricted space or group of spaces.

b) Escape from spaces below the lowest open deck

Below the lowest open deck the main means of escape shall be a stairway and the second escape may be a trunk or a stairway.

c) Escape from spaces above the lowest open deck Above the lowest open deck the means of escape shall be stairways or doors to an open deck or a combination thereof.

d) Dead-end corridors

No dead-end corridors having a length of more than 7 m shall be accepted.

e) Width and continuity of escape routes

The width, number and continuity of escape routes shall be in accordance with the requirements in Sec 13.

f) Dispensation from two means of escape

Exceptionally the Society may dispense with one of the means of escape, for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors.

2.3 Means of escape from machinery spaces

2.3.1 Application

The provisions of 2.3.2 apply to passenger ships, those of 2.3.3 apply to cargo ships.

2.3.2 Means of escape on passenger ships

Means of escape from each machinery space in passenger ships shall comply with the following provisions:

a) Escape from spaces below the bulkhead deck

Where the space is below the bulkhead deck, the two means of escape shall consist of either:

1) two sets of steel ladders as widely separated as possible, leading to doors in the upper part of the space, similarly separated and from which access is provided to the appropriate lifeboat and liferaft embarkation decks. One of these ladders shall be located within a protected enclosure that satisfies Sec 5, 1.3.3, category (2), or Sec 5, 1.3.4, category (4), as appropriate, from the lower part of the space it serves to a safe position outside the space.

   Self-closing fire doors of the same fire integrity standards shall be fitted in the enclosure. The ladder shall be fixed in such a way that heat is not transferred into the enclosure through non-insulated fixing points. The protected enclosure shall have minimum internal dimensions of at least 800 mm x 800 mm, and shall have emergency lighting provisions, or

2) one steel ladder leading to a door in the upper part of the space from which access is provided to the embarkation deck and additionally, in the lower part of the space and in a position well separated from the ladder referred to, a steel door capable of being operated from each side and which provides access to a safe escape route from the lower part of the space to the embarkation deck.

b) Escape from spaces above the bulkhead deck

Where the space is above the bulkhead deck, the two means of escape shall be as widely separated as possible and the doors leading from such means of escape shall be in a position from which access is provided to the appropriate lifeboat and liferaft embarkation decks.

Where such means of escape require the use of ladders, these shall be of steel.

c) Dispensation from two means of escape

In a ship of less than 1000 gross tonnage, the Society may dispense with one of the means of escape, due regard being paid to the width and disposition of the upper part of the space. In a ship of 1000 gross tonnage and above, the Society may dispense with one means of escape from any such space, including a normally unattended auxiliary machinery space, so long as either a door or a steel ladder provides a safe escape route to the embarkation deck, due regard being paid to the nature and location of the space and whether persons are normally employed in that space. In the steering gear space, a second means of escape shall be provided when the emergency steering position is located in that space unless there is direct access to the open deck.

d) Escape from machinery control rooms

Two means of escape shall be provided from a machinery control room located within a machinery space, at

least one of which will provide continuous fire shelter to a safe position outside the machinery space.

2.3.3 Means of escape on cargo ships

Means of escape from each machinery space in cargo ships shall comply with the following provisions:

a) Escape from machinery spaces of category A

Except as provided in the following item b), two means of escape shall be provided from each machinery space of category A. In particular, one of the following provisions shall be complied with:

1) two sets of steel ladders, as widely separated as possible, leading to doors in the upper part of the space, similarly separated and from which access is provided to the open deck. One of these ladders shall be located within a protected enclosure that satisfies Ch. 4, Sec. 5, 1.4.3, category (4), from the lower part of the space it serves to a safe position outside the space. Self-closing fire doors of the same fire integrity standards shall be fitted in the enclosure. The ladder shall be fixed in such a way that heat is not transferred into the enclosure through non-insulated fixing points. The enclosure shall have minimum internal dimensions of at least 800 mm x 800 mm, and shall have emergency lighting provisions, or

2) one steel ladder leading to a door in the upper part of the space from which access is provided to the open deck and, additionally, in the lower part of the space and in a position well separated from the ladder referred to, a steel door capable of being operated from each side and which provides access to a safe escape route from the lower part of the space to the open deck.

b) Dispensation from two means of escape

In a ship of less than 1000 gross tonnage, the Society may dispense with one of the means of escape required under item a), due regard being paid to the dimension and disposition of the upper part of the space.

In addition, the means of escape from machinery spaces of category A need not comply with the requirement for an enclosed fire shelter listed in item a) 1) above. In the steering gear space, a second means of escape shall be provided when the emergency steering position is located in that space unless there is direct access to the open deck.

c) Escape from machinery spaces other than those of category A

From machinery spaces other than those of category A, two escape routes shall be provided except that a single escape route may be accepted for spaces that are entered only occasionally and for spaces where the maximum travel distance to the door is 5 m or less.

2.4 Means of escape on passenger ships from special category and open ro-ro spaces to which any passengers carried can have access

2.4.1 In special category and open ro-ro spaces to which any passengers carried can have access, the number and locations of the means of escape both below and above the bulkhead deck shall be to the satisfaction of the Society and, in general, the safety of access to the embarkation deck shall be at least equivalent to that provided for in items a) 1), b), d) 1) and d) 2) of 2.2.3.

2.4.2 Direct access to special category spaces

One of the escape routes from the machinery spaces where the crew is normally employed shall avoid direct access to any special category space.

2.5 Means of escape from ro-ro spaces

2.5.1 At least two means of escape shall be provided in roro spaces where the crew are normally employed. The escape routes shall provide a safe escape to the lifeboat and liferaft embarkation decks and shall be located at the fore and aft ends of the space.

2.6 Additional requirements for ro-ro passenger ships

2.6.1 General

a) Escape routes shall be provided from every normally occupied space on the ship to an assembly station.

These escape routes shall be arranged so as to provide the most direct route possible to the assembly station, and shall be marked with symbols in accordance with the recommendations of IMO Resolution A.760 (18).

b) The escape route from cabins to stairway enclosures shall be as direct as possible, with a minimum number of changes in direction. It shall not be necessary to cross from one side of the ship to the other to reach an escape route. It shall not be necessary to climb more than two decks up or down in order to reach an assembly station or open deck from any passenger space.

c) External routes shall be provided from open decks, as referred to in item b), to the survival craft embarkation stations.

d) Where enclosed spaces adjoin an open deck, openings from the enclosed space to the open deck shall, where practicable, be capable of being used as an emergency exit.

e) Escape routes shall not be obstructed by furniture and other obstructions. With the exception of tables and chairs which may be cleared to provide open space, cabinets and other heavy furnishings in public spaces and along escape routes shall be secured in place to prevent shifting if the ship rolls or lists. Floor coverings shall also be secured in place. When the ship is under way, escape routes shall be kept clear of obstructions such as cleaning carts, bedding, luggage and boxes of goods.

2.6.2 Instruction for safe escape

a) Decks shall be sequentially numbered, starting with "1" at the tank top or lowest deck. The numbers shall be prominently displayed at stair landings and lift lobbies. Decks may also be named, but the deck number shall always be displayed with the name.

b) Simple "mimic" plans showing the "you are here" position and escape routes marked by arrows shall be prominently displayed on the inside of each cabin door and in public spaces. The plan shall show the directions of escape and shall be properly oriented in relation to its position on the ship.

2.6.3 Strength of handrails and corridors

a) Handrails or other handholds shall be provided in corridors along the entire escape route so that a firm handhold is available at every step of the way, where possible, to the assembly stations and embarkation stations.

Such handrails shall be provided on both sides of longitudinal corridors more than 1.8 m in width and transverse corridors more than 1 m in width. Particular attention shall be paid to the need to be able to cross lobbies, atriums and other large open spaces along escape routes. Handrails and other handholds shall be of such strength as to withstand a distributed horizontal load of 750 N/m applied in the direction of the centre of the corridor or space, and a distributed vertical load of 750 N/m applied in the downward direction. The two loads need not be applied simultaneously.

b) The lowest 0.5 m of bulkheads and other partitions forming vertical divisions along escape routes shall be able to sustain a load of 750 N/m to allow them to be used as walking surfaces from the side of the escape route with the ship at large angles of heel.

2.6.4 Evacuation analysis

Escape routes shall be evaluated by an evacuation analysis early in the design process. The analysis shall be used to identify and eliminate, as far as practicable, congestion which may develop during an abandonment, due to normal movement of passengers and crew along escape routes, including the possibility that crew may need to move along these routes in a direction opposite to the movement of passengers.

In addition, the analysis shall be used to demonstrate that escape arrangements are sufficiently flexible to provide for the possibility that certain escape routes, assembly stations, or embarkation stations of survival craft may not be available as a result of a casualty.

Section 9 Fire Control Plans

1 Application

1.1 General

1.1.1 This Section applies to passenger ships and cargo ships.

2 Fire control plans

2.1 Compilation of the fire control plans

2.1.1 General arrangement plans shall be permanently exhibited for the guidance of the ship's officers, showing clearly for each deck the control stations, the various fire sections enclosed by A class divisions, the sections enclosed by B class divisions together with particulars of the fire detection and fire alarm systems, the sprinkler installation, the fire-extinguishing appliances, means of access to different compartments, decks, etc. and the ventilating system, including particulars of the fan control positions, the position of dampers and identification numbers of the ventilating fans serving each section, and the position of fuel oil quick-closing valve remote control and fuel oil pump stops.

Alternatively, at the discretion of the Society, the aforementioned details may be set out in a booklet, a copy of which shall be supplied to each officer, and one copy shall at all times be available on board in an accessible position. Plans and booklets shall be kept up to date; any alterations thereto shall be recorded as soon as practicable. Description in such plans and booklets shall be in the language or languages required by the Society. If the language is neither English nor Persian, a translation into one of those languages shall be included.

In addition, instructions concerning the maintenance and operation of all the equipment and installations on board for the fighting and containment of fire shall be kept under one cover, readily available in an accessible position.

2.1.2 In ships carrying more than 36 passengers, plans and booklets required by 2.1.1 shall provide information regarding fire protection, fire detection and fire extinction based on the guidelines of IMO Resolution A.756 (18).

Note 1: IMO Resolution A.756 (18) requires the following information to be provided with the fire control plans and available at all times:

- ship's keel laying date and application of the SOLAS Convention and amendments. Original method (I, II, III or with or without sprinklers etc.) of fire safety construction, as applicable
- which additional fire safety measures, if any, were applied
- dates and description of any modifications to the ship which in any way alter its fire safety
- if the information required by the above item is not available for modifications carried out before 1 October 1994, at least the fire safety method (I, II, III or the SOLAS Convention and amendments thereto) as presently used in the ship is to be stated. Where more than one method or a

combination of methods is used in different locations of the ship, this is to be specified.

2.1.3 Special equipment provided for the carriage of dangerous goods, if fitted, is to be shown.

2.2 Location of the fire control plans

2.2.1 A duplicate set of fire control plans or a booklet containing such plans shall be permanently stored in a prominently marked weathertight enclosure outside the deckhouse for the assistance of shore-side fire-fighting personnel.

Section 10 Helicopter Facilities

1 General

1.1 Application

1.1.1 In addition to complying with the requirements of the other Subsections of this Section, as appropriate, ships equipped with helicopter facilities are to comply with those of this Section.

Items e) and f) of 3.1.1 and articles 5 and 6 do not contain requirements applicable for the purpose of classification; they have been reproduced for reference purposes only.

1.2 Contents

1.2.1 This Section includes the provisions of IMO Resolution A.855 (20) of 27 November 1997.

1.3 Definitions

1.3.1 Helideck

Helideck is a purpose-built helicopter landing area located on a ship including all structure, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

1.3.2 Helicopter facilities

Helicopter facility is a helideck including any refuelling and hangar facilities.

2 Structure

2.1 Construction of steel or other equivalent materials

2.1.1 In general, the construction of the helidecks shall be of steel or other equivalent materials. If the helideck forms the deckhead of a deckhouse or superstructure, it shall be insulated to A-60 class standard.

2.2 Construction of aluminium or other low melting point metals

2.2.1 If the Society permits aluminium or other low melting point metal construction that is not made equivalent to steel and if the platform is located above the ship's deckhouse or similar structure, the following conditions shall be satisfied:

a) the deckhouse top and bulkheads under the platform shall have no opening

b) windows under the platform shall be provided with steel shutters.

2.3 Means of escape

2.3.1 A helideck shall be provided with both a main and an emergency means of escape and access for fire-fighting and rescue personnel. These shall be located as far apart from each other as is practicable and preferably on opposite sides of the helideck.

3 Fire-fighting appliances

3.1 General

3.1.1 In close proximity to the helideck, the following firefighting appliances shall 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 helicopters can operate. The system shall be capable of delivering a discharge rate as required in Tab 2.1 for at least five minutes

d) The principal agent is to meet the applicable performance standards of the International Civil Aviation Organization - 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

e) at least two nozzles of an approved dual-purpose type (jet/spray) and hoses sufficient to reach any part of the helideck

f) two sets of fire-fighter's outfits, and

g) 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
- lift line 5 mm diameter and 15 m in length
- pliers, side-cutting
- set of assorted screwdrivers, and
- harness knife complete with sheath.

Table 2.1: Foam discharge rates

Category	Helicopter overall length	Discharge rate foam solution (l/min)
H1	up to but not including 15 m	250
H2	from 15 m up to but not including 24 m	500
H3	from 24 m up to but not including 35 m	800

3.2 Drainage facilities

3.2.1 Drainage facilities in way of helidecks shall be constructed of steel and shall lead directly overboard independent of any other system and shall be designed so that drainage does not fall onto any part of the ship.

4 Helicopter refuelling and hangar facilities

4.1 Fuel storage system

4.1.1 Storage area

a) A designated area shall be provided for the storage of fuel tanks which shall 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 shall be provided with arrangements whereby fuel spillage may be collected and drained to a safe location.

4.1.2 Fuel tanks

a) Tanks and associated equipment shall be protected against physical damage and from a fire in an adjacent space or area.

b) Where portable fuel storage tanks are used, special attention shall be given to:

1) design of the tank for its intended purpose

2) mounting and securing arrangements

3) electric bonding, and

4) inspection procedures.

4.1.3 Fuel pumping

a) Storage tank fuel pumps shall be provided with means which permit shutdown from a safe remote location in the event of a fire. Where a gravity fuelling system is installed, equivalent closing arrangements shall be provided to isolate the fuel source.

b) The fuel pumping unit shall be connected to one tank at a time. The piping between the tank and the pumping unit shall be of steel or equivalent material, as short as possible, and protected against damage.

c) Electrical fuel pumping units and associated control equipment shall be of a type suitable for the location and potential hazards.

d) Fuel pumping units shall incorporate a device which will prevent over-pressurization of the delivery or filling hose.

4.1.4 Refuelling equipment

Equipment used in refuelling operations shall be electrically bonded.

4.2 "No smoking" signs

4.2.1 "NO SMOKING" signs shall be displayed at appropriate locations.

4.3 Hangar, refuelling and maintenance facilities

4.3.1 Hangar, refuelling and maintenance facilities shall be treated as category A machinery spaces with regard to structural fire protection, fixed fire-extinguishing and detection system requirements.

4.4 Arrangement of spaces containing the refuelling installations

4.4.1 Ventilation

Enclosed hangar facilities or enclosed spaces containing refuelling installations shall be provided with mechanical ventilation as required by Sec 12, 2 for closed ro-ro spaces of cargo ships. Ventilation fans shall be of non-sparking type (see Part 5, Ch 7).

4.4.2 Electric equipment and wiring

Electric equipment and wiring in enclosed hangars or enclosed spaces containing refuelling installations shall comply with the requirements of Sec 12, 2.2, 2.3 and 2.4.

5 Occasional and emergency helicopter operations

5.1 General

5.1.1 Where helicopters land or conduct winching operations on an occasional or emergency basis on ships without helidecks, fire-fighting equipment fitted in accordance with the requirements of Sec 1 may be used. This equipment shall be made readily available in close proximity to the landing or winching areas during helicopter operations.

6 Operations manual

6.1 General

6.1.1 Each helicopter facility shall have an operations manual, including a description and a checklist of safety precautions, procedures and equipment requirements. This manual may be part of the ship's emergency response procedures.

Section 11 Carriage of Dangerous Goods

1 General requirements

1.1 Application

1.1.1 In addition to complying with the requirements of the other Subsections of this Section, as appropriate, ship types and cargo spaces, referred to in 1.1.2, intended for the carriage of dangerous goods shall comply with the requirements of this Section, as appropriate, except when carrying dangerous goods in limited quantities in the judgement of the Society, unless such requirements have already been met by compliance with the requirements elsewhere in this Section. The types of ships and modes of carriage of dangerous goods are referred to in 1.1.2 and in Table 1.1, where the items of the list in 1.1.2 are referred to in the head of table.

Cargo ships of less than 500 gross tonnage shall comply with this Section, but the Society may reduce the requirements and such reduced requirements shall be recorded in the document of compliance referred to in MSC/Circ. 642.

Note 1: “limited quantities“ as per the IMO “International Maritime Dangerous Goods Code” (IMDG Code).

1.1.2 The following ship types and cargo spaces shall govern the application of Table 1.1 and Table 1.2:

a) Ships and cargo spaces not specifically designed for the carriage of freight containers, but intended for the carriage of dangerous goods in packaged form, including goods in freight containers and portable tanks

b) Purpose-built containerships and cargo spaces intended for the carriage of dangerous goods in freight containers and portable tanks (see 1.1.2, Note 1)

c) Ro-ro ships and ro-ro spaces intended for the carriage of dangerous goods (see 1.1.2, Note 2 and 1.1.2, Note 3)

d) Ships and cargo spaces intended for the carriage of solid dangerous goods in bulk, and

e) Ships and cargo spaces intended for carriage of dangerous goods other than liquids and gases in bulk in shipborne barges.

Note 1: A purpose-built container space is a cargo space fitted with cell guides for stowage and securing of containers.

Note 2: Ro-ro spaces include special category spaces and vehicle spaces.

Note 3: A Ro-ro space completely exposed to the weather from above and from at least two sides is considered as a weather deck.

2 Special requirements

2.1 General

2.1.1 Unless otherwise specified, the following requirements shall govern the application of Table 1.1, Table 1.2 and Table 2.1 to both "on-deck" and "under-deck" stowage of dangerous goods where the numbers of following 2.2 to 2.11 are indicated in the first column of the tables.

2.2 Water supplies

2.2.1 Arrangements shall be made to ensure immediate availability of a supply of water from the fire main at the required pressure either by permanent pressurisation or by suitably placed remote arrangements for the fire pumps.

2.2.2 The quantity of water delivered shall be capable of supplying four nozzles of a size and at pressures as specified in Sec 6, 1.2.6, capable of being trained on any part of the cargo space when empty. This amount of water may be applied by equivalent means to the satisfaction of the Society.

2.2.3 Means shall be provided for effectively cooling the designated under-deck cargo space by at least 5 l/min per square metre of the horizontal area of cargo spaces, either by a fixed arrangement of spraying nozzles or by flooding the cargo space with water. Hoses may be used for this purpose in small cargo spaces and in small areas of larger cargo spaces at the discretion of the Society. However, the drainage and pumping arrangements shall be such as to prevent the build-up of free surfaces. The drainage system shall be sized to remove no less than 125% of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles. The drainage system valves shall be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells shall be of sufficient holding capacity and shall be arranged at the side shell of the ship at a distance from each other of not more than 40 m in each watertight compartment. If this is not possible, the adverse effect upon stability of the added weight and free surface of water shall be taken into account to the extent deemed necessary by the Society in its approval of the stability information.

2.2.4 Provision to flood a designated under-deck cargo space with suitable specified media may be substituted for the requirements in 2.2.3.

A high expansion foam system complying with Sec 13 is acceptable unless cargoes react dangerously with water (see the IMO “International Maritime Dangerous Goods Code”).

2.2.5 The total required capacity of the water supply shall satisfy the requirements of 2.2.2 and 2.2.3, if applicable, simultaneously calculated for the largest designed cargo space. The capacity requirements of 2.2.2 shall be met by the total capacity of the main fire pump(s), not including the capacity of the emergency fire pump, if fitted. If a drencher system is used to satisfy the requirements of 2.2.3, the drencher pump shall also be taken into account in this total capacity calculation.

Table 1.1: Application of the requirements to different modes of carriage of dangerous goods in ships and cargo spaces

Requirements of Article 2	Requirement 1.1.2						
	Weather decks a) to e) inclusive	a	b	c		d	e
		Not specifically designed	Container cargo spaces	Closed ro-ro spaces (5)	Open ro-ro spaces	Solid dangerous goods in bulk	Shipborne barges
2.2.1	X	X	X	X	X	For application of requirements of Ch 4, Sec 11 to different classes of dangerous goods, see Tab 2	X
2.2.2	X	X	X	X	X		-
2.2.3	--	X	X	X	X		X
2.2.4	-	X	X	X	X		X
2.3	-	X	X	X	X		X (4)
2.4	-	X	X	X	-		X (4)
2.5.1	-	X	X (1)	X	-		X (4)
2.5.2	-	X	X (1)	X	-		X (4)
2.6	-	X	X	X	-		-
2.7.1	X	X	X	X	X		-
2.7.2	X	X	X	X	X		-
2.8	X	X	-	-	X		-
2.9	X	X	X (2)	X	X		-
2.10	-	-	-	X (3)	X		-
2.11.1	-	-	-	X	-		-
2.11.2	-	-	-	X	-		-

x : Where “x” appears in the Table, it means that this requirement is applicable to all classes of dangerous goods as given in the appropriate line of Table 2.1, except as indicated by the following notes.

(1) For classes 4 and 5.1, not applicable to closed freight containers.

For classes 2, 3, 6.1 and 8 when carried in closed freight containers, the ventilation rate may be reduced to not less than two air changes. For the purpose of this requirement, a portable tank is a closed freight container.

(2) Applicable to decks only.

(3) Applies only to closed ro-ro spaces, not capable of being sealed.

(4) In the special case where the barges are capable of containing flammable vapours or, alternatively, if they are capable of discharging flammable vapours to a safe space outside the barge carrier compartment by means of ventilation ducts connected to the barges, these requirements may be reduced or waived to the satisfaction of the Society.

(5) Special category spaces shall be treated as closed ro-ro spaces when dangerous goods are carried.

Table 1.2: Application of the requirements to different classes of dangerous goods for ships and cargo spaces carrying solid dangerous goods in bulk

Requirements of Article 2	Class						
	4.1	4.2	4.3 (1)	5.1	6.1	8	9
2.2.1	X	X	-	X	-	-	X
2.2.2	X	X	-	X	-	-	X
2.3	X	X(2)	X	X(3)	-	-	X(3)
2.5.1	-	X(2)	X	-	-	-	-
2.5.2	X(4)	X(2)	X	X (2) (4)	-	-	X (2) (4)
2.5.3	X	X	X	X	X	X	X
2.7	X	X	X	X	X	X	X
2.9	X	X	X	X (2)	-	-	X(5)

(1) The hazards of substances in this class which may be carried in bulk are such that special consideration shall be given by the Society to the construction and equipment of the ship involved in addition to meeting the requirements enumerated in this Table.

(2) Only applicable to Seedcake containing solvent extractions, to Ammonium nitrate and to Ammonium nitrate fertilizers.

(3) Only applicable to Ammonium nitrate and to Ammonium nitrate fertilizers. However, a degree of protection in accordance with standards contained in the “International Electrotechnical Commission, publication 60079 - Electrical Apparatus for Explosive Gas Atmospheres” is sufficient.

(4) Only suitable wire mesh guards are required.

(5) The requirements of the “Code of Safe Practice for Solid Bulk Cargoes” adopted by IMO Resolution A.434 (XI), as amended, are sufficient.

Table 2.1: Application of the requirements to different classes of dangerous goods except solid dangerous goods in bulk

Requirements of Article [2]	Class																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	1.1 to 1.6	1.4S	2.1	2.2	2.3	3.1 3.2 liquids ≤ 23°C (5)	3.3 liquids > 23°C (5) ≤ 61°C	4.1	4.2	4.3	5.1	5.2	6.1 liquids	6.1 liquids ≤ 23°C (5)	6.1 liquids > 23°C (5) ≤ 61°C	6.1 solids	8 liquids	8 liquids ≤ 23°C (5)	8 liquids > 23°C (5) ≤ 61°C	8 solids	9
[2.2.1]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
[2.2.2]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
[2.2.3]	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
[2.2.4]	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
[2.3]	x	–	x	–	–	x	–	–	–	–	–	–	–	x	–	–	–	x	–	–	–
[2.4]	x	x	x	x	x	x	x	x	x	x	x	–	x	x	x	x	x	x	x	x	–
[2.5.1]	–	–	x	–	x	x	–	x (1)	x (1)	x	x (1)	–	–	x	x	x (1)	–	x	x	–	x (1)
[2.5.2]	–	–	x	–	–	x	–	–	–	–	–	–	–	x	x	–	–	x	x	–	–
[2.6]	–	–	–	–	–	x	–	–	–	–	–	–	x	x	x	–	–	x	–	–	–
[2.7]	–	–	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x (4)
[2.8]	–	–	–	–	–	x	x	x	x	x	x	–	–	x	x	–	–	x	x	–	–
[2.9]	x (2)	–	x	x	x	x	x	x	x	x	x (3)	–	–	x	x	–	–	x	x	–	–
[2.10]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
[2.11.1]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
[2.11.2]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

(1) When “mechanically ventilated spaces” are required by the ”International Maritime Dangerous Goods Code” (IMDG Code), as amended.

(2) Stow 3 m horizontally away from the machinery space boundaries in all cases.

(3) Refer to the “International Maritime Dangerous Goods Code”, as amended.

(4) As appropriate to the goods to be carried.

(5) Refers to flashpoint.

2.3 Sources of ignition

2.3.1 Electrical equipment and wiring shall not be fitted in enclosed cargo spaces or vehicle spaces unless it is essential for operational purposes in the opinion of the Society. However, if electrical equipment is fitted in such spaces, it shall be of a certified safe type for use in the dangerous environments to which it may be exposed unless it is possible to completely isolate the electrical system (e.g. by removal of links in the system, other than fuses). Cable penetrations of the decks and bulkheads shall be sealed against the passage of gas or vapour. Through runs of cables and cables within the cargo spaces shall be protected against damage from impact. Any other equipment which may constitute a source of ignition of flammable vapour shall not be permitted.

2.4 Detection system

2.4.1 Ro-ro spaces shall be fitted with a fixed fire detection and fire alarm system complying with the requirements of Sec 13. All other types of cargo spaces shall be fitted with either a fixed fire detection and fire alarm system or a sample extraction smoke detection system complying with the requirements of Sec 13. If a sample extraction smoke detection system is fitted, particular attention shall be given to item c) of Sec 13, [9.1.1] in order to prevent the leakage of toxic fumes into occupied areas.

2.5 Ventilation

2.5.1 Adequate power ventilation shall be provided in enclosed cargo spaces. The arrangement shall be such as to provide for at least six air changes per hour in the cargo space, based on an empty cargo space, and for removal of vapours from the upper or lower parts of the cargo space, as appropriate.

2.5.2 The fans shall be such as to avoid the possibility of ignition of flammable gas/air mixtures. Suitable wire mesh guards shall be fitted over inlet and outlet ventilation openings.

Exhaust fans are to be of non-sparking type.

2.5.3 Natural ventilation shall be provided in enclosed cargo spaces intended for the carriage of solid dangerous goods in bulk, where there is no provision for mechanical ventilation.

2.6 Bilge pumping

2.6.1 Where it is intended to carry flammable or toxic liquids in enclosed cargo spaces, the bilge pumping system shall be designed to protect against inadvertent pumping of such liquids through machinery space piping or pumps.

Where large quantities of such liquids are carried, consideration shall be given to the provision of additional means of draining those cargo spaces. These means shall be to the satisfaction of the Society.

2.6.2 Cargo spaces intended for carriage of flammable liquids with flashpoint less than 23°C or toxic liquids are to be fitted with a fixed bilge drainage system independent of or separated from the bilge system in the machinery space and located outside such space.

If a single bilge drainage system completely independent of the machinery space is provided, the system is to comply with the requirements of Sec 10.

2.6.3 If the bilge drainage system is additional to the system served by pumps in the machinery space, the capacity of the system shall be not less than 10 m^3/h per cargo space served. If the additional system is common, the capacity need not exceed 25 m^3/h. The additional bilge system need not be arranged with redundancy.

2.6.4 Whenever flammable liquids with flashpoint less than 23°C or toxic liquids are carried, the bilge line into the machinery space shall be isolated either by fitting a blank flange or by a closed lockable valve.

2.6.5 Enclosed spaces outside machinery spaces containing bilge pumps serving cargo spaces intended for carriage of flammable or toxic liquids shall be fitted with separate mechanical ventilation giving at least 6 air changes per hour. Electrical equipment in the space is to be in accordance with Chapter 2. If the space has access from another enclosed space, the door shall be self-closing.

2.6.6 If bilge drainage of cargo spaces is arranged by gravity drainage, the drainage shall be either led directly overboard or to a closed drain tank located outside the machinery spaces. The tank shall be provided with a vent pipe to a safe location on the open deck. Drainage from a cargo space into bilge wells in a lower space is only permitted if that space satisfies the same requirements as the cargo space above.

2.7 Personnel protection

2.7.1 Four sets of full protective clothing, resistant to chemical attack, shall be provided in addition to the fire-fighter's outfits required by SOLAS, chapter II-2, regulation 10.10. The protective clothing shall cover all skin, so that no part of the body is unprotected.

2.7.2 At least two self-contained breathing apparatuses additional to those required by SOLAS, chapter II-2, regulation 10 shall be provided. Two spare charges suitable for use with the breathing apparatus shall be provided for each required apparatus. Passenger ships carrying not more than 36 passengers and cargo ships that are equipped with suitably located means for fully recharging the air cylinders free from contamination need carry only one spare charge for each required apparatus.

2.8 Portable fire extinguishers

2.8.1 Portable fire extinguishers with a total capacity of at least 12 kg of dry powder or equivalent shall be provided for the cargo spaces. These extinguishers shall be in addition to any portable fire extinguishers required elsewhere in this Section.

2.9 Insulation of machinery space boundaries

2.9.1 Bulkheads forming boundaries between cargo spaces and machinery spaces of category A shall be insulated to A- 60 class standard, unless the dangerous goods are stowed at least 3 m horizontally away from such bulkheads. Other boundaries between such spaces shall be insulated to A-60 class standard.

2.10 Water-spray system

2.10.1 Each open ro-ro space having a deck above it and each space deemed to be a closed ro-ro space not capable of being sealed shall be fitted with an approved fixed pressure water-spraying system for manual operation which shall protect all parts of any deck and vehicle platform in the space, except that the Society may permit the use of any other fixed fire-extinguishing system that has been shown by full-scale test to be no less effective. However, the drainage and pumping arrangements shall be such as to prevent the build-up of free surfaces. The drainage system shall be sized to remove no less than 125% of the combined capacity of both the water-spraying system pumps and the required number of fire hose nozzles. The drainage system valves shall be operable from outside the protected space at a position in the vicinity of the extinguishing system controls.

Bilge wells shall be of sufficient holding capacity and shall be arranged at the side shell of the ship at a distance from each other of not more than 40 m in each watertight compartment.

If this is not possible, the adverse effect upon stability of the added weight and free surface of water shall be taken into account to the extent deemed necessary by the Society in its approval of the stability information.

2.11 Separation of ro-ro spaces

2.11.1 In ships having ro-ro spaces, a separation shall be provided between a closed ro-ro space and an adjacent open ro-ro space. The separation shall be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, such separation need not be provided if the ro-ro space is considered to be a closed cargo space over its entire length and fully complies with the relevant special requirements of this Section.

2.11.2 In ships having ro-ro spaces, a separation shall be provided between a closed ro-ro space and the adjacent weather deck. The separation shall be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, a separation need not be provided if the arrangements of the closed ro-ro spaces are in accordance with those required for the dangerous goods carried on adjacent weather decks.

Section 12 Protection of Vehicle, Special Category and Ro-Ro Spaces

1 General requirements

1.1 Application

1.1.1 In addition to complying with the requirements of the other Subsections of this Section, as appropriate, vehicle, special category and ro-ro spaces shall comply with the requirements of the present Section.

1.2 Basic principles for passenger ships

1.2.1 The basic principle underlying the provisions of this Section is that the main vertical zoning required by Sec 5, 1 may not be practicable in vehicle spaces of passenger ships and, therefore, equivalent protection must be obtained in such spaces on the basis of a horizontal zone concept and by the provision of an efficient fixed fire-extinguishing system. Based on this concept, a horizontal zone for the purpose of this Section may include special category spaces on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m.

1.2.2 The basic principle underlying the provisions of 1.2.1 is also applicable to ro-ro spaces.

1.2.3 The requirements of ventilation systems, openings in A class divisions and penetrations in A class divisions for maintaining the integrity of vertical zones in this Section shall be applied equally to decks and bulkheads forming the boundaries separating horizontal zones from each other and from the remainder of the ship.

2 Precaution against ignition of flammable vapours in closed vehicle spaces, closed ro-ro spaces and special category spaces

2.1 Ventilation systems

2.1.1 Capacity of ventilation systems

There shall be provided an effective power ventilation system sufficient to give at least the following air changes:

a) Passenger ships:

- Special category spaces: 10 air changes per hour
- Closed ro-ro and vehicle spaces other than special category spaces for ships carrying more than 36 passengers: 10 air changes per hour
- Closed ro-ro and vehicle spaces other than special category spaces for ships carrying not more than 36 passengers: 6 air changes per hour

b) Cargo ships: 6 air changes per hour.

The Society may require an increased number of air changes when vehicles are being loaded and unloaded.

2.1.2 Performance of ventilation systems

a) In passenger ships, the power ventilation system required in 2.1.1 shall be separate from other ventilation systems and shall be in operation at all times when vehicles are in such spaces. Ventilation ducts serving such cargo spaces capable of being effectively sealed shall be separated for each such space. The system shall be capable of being controlled from a position outside such spaces.

b) In cargo ships, ventilation fans shall normally be run continuously whenever vehicles are on board. Where this is impracticable, they shall be operated for a limited period daily as weather permits and in any case for a reasonable period prior to discharge, after which period the ro-ro or vehicle space shall be proved gas-free. One or more portable combustible gas detecting instruments shall be carried for this purpose. The system shall be entirely separate from other ventilating systems. Ventilation ducts serving ro-ro or vehicle spaces shall be capable of being effectively sealed for each cargo space. The system shall be capable of being controlled from a position outside such spaces.

c) In passenger and cargo ships, the ventilation system shall be such as to prevent air stratification and the formation of air pockets.

d) Fans are to be of non-sparking type.

2.1.3 Indication of ventilation systems

Means shall be provided on the navigation bridge to indicate any loss of the required ventilating capacity.

2.1.4 Closing appliances and ducts

a) Arrangements shall be provided to permit a rapid shutdown and effective closure of the ventilation system from outside of the space in case of fire, taking into account the weather and sea conditions.

b) Ventilation ducts, including dampers, within a common horizontal zone shall be made of steel. In passenger ships, ventilation ducts that pass through other horizontal zones or machinery spaces shall be A-60 class steel ducts constructed in accordance with Sec 5, 6.3.1.

2.1.5 Permanent openings

Permanent openings in the side plating, the ends or deckhead of the space shall be so situated that a fire in the cargo space does not endanger stowage areas and embarkation stations for survival craft and accommodation spaces, service spaces and control stations in superstructures and deckhouses above the cargo spaces.

2.2 Electrical equipment and wiring

2.2.1 Except as provided in 2.2.2, electrical equipment and wiring shall be of a type suitable for use in an explosive petrol and air mixture.

2.2.2 In case of other than special category spaces below the bulkhead deck, notwithstanding the provisions in 2.2.1, above a height of 450 mm from the deck and from each platform of vehicles, if fitted, except platforms with openings of sufficient size permitting penetration of petrol gases downwards, electrical equipment of a type so enclosed and protected as to prevent the escape of sparks shall be permitted as an alternative, on condition that the ventilation system is so designed and operated as to provide continuous ventilation of the cargo spaces at the rate of at least ten air changes per hour whenever vehicles are on board.

2.3 Electrical equipment and wiring in exhaust ventilation ducts

2.3.1 Electrical equipment and wiring, if installed in an exhaust ventilation duct, shall be of a type approved for use in explosive petrol and air mixtures and the outlet from any exhaust duct shall be sited in a safe position, having regard to other possible sources of ignition.

2.4 Other ignition sources

2.4.1 Other equipment which may constitute a source of ignition of flammable vapours shall not be permitted.

2.5 Scuppers and discharges

2.5.1 Scuppers shall not be led to machinery or other spaces where sources of ignition may be present.

3 Detection and alarm

3.1 Fixed fire detection and fire alarm systems

3.1.1 There shall be provided a fixed fire detection and fire alarm system complying with the requirements of Sec 13. The fixed fire detection system shall be capable of rapidly detecting the onset of fire. The type of detectors and their spacing and location shall be to the satisfaction of the Society, taking into account the effects of ventilation and other relevant factors. After being installed, the system shall be tested under normal ventilation conditions and shall give an overall response time to the satisfaction of the Society.

Fire detectors are to be smoke detectors.

3.2 Sample extraction smoke detection systems

3.2.1 Except open ro-ro spaces, open vehicle spaces and special category spaces, a sample extraction smoke detection system complying with the requirements of Sec 13 may be used as an alternative for the fixed fire detection and fire alarm system required in 3.1.

3.3 Special category spaces

3.3.1 Manually operated call points shall be spaced so that no part of the space is more than 20 m from a manually operated call point, and one shall be placed close to each exit from such spaces.

4 Structural protection

4.1 General

4.1.1 Notwithstanding the provisions of Sec 5, 1.3, in passenger ships carrying more than 36 passengers, the boundary bulkheads and decks of special category spaces and ro-ro spaces shall be insulated to A-60 class standard.

However, where a category (5), (9) or (10) space, as defined in Ch 4, Sec 5, [1.3.3] is on one side of the division, the standard may be reduced to A-0. Where fuel oil tanks are below a special category space or a ro-ro space, the integrity of the deck between such spaces may be reduced to A-0 standard.

5 Fire extinction

5.1 Fixed fire-extinguishing systems

5.1.1 Vehicle spaces and ro-ro spaces which are not special category spaces and are capable of being sealed from a location outside of the cargo spaces shall be fitted with a fixed gas fire-extinguishing system which shall comply with the provisions of Sec 13, except that:

a) if a carbon dioxide fire-extinguishing system is fitted, the quantity of gas available shall be at least sufficient to give a minimum volume of free gas equal to 45% of the gross volume of the largest such cargo space which is capable of being sealed, and the arrangements shall be such as to ensure that at least two thirds of the gas required for the relevant space shall be introduced within 10 minutes

b) any other fixed inert gas fire-extinguishing system or fixed high-expansion foam fire-extinguishing system may be fitted provided the Society is satisfied that an equivalent protection is achieved, and

c) as an alternative, a fire-extinguishing system meeting the requirements of 5.1.2 may be fitted.

5.1.2 Ro-ro and vehicle spaces not capable of being sealed and special category spaces shall be fitted with an approved fixed pressure water-spraying system complying with the requirements of Sec 13.

5.1.3 The Society may permit the use of any other fixed fireextinguishing system that has been shown, by a full-scale test in conditions simulating a flowing petrol fire in a vehicle space or a ro-ro space, to be not less effective in controlling fires likely to occur in such a space.

5.1.4 When fixed pressure water-spraying fire-extinguishing systems are provided, in view of the serious loss of stability which could arise due to large quantities of water accumulating on the deck or decks during the operation of the water-spraying system, the following arrangements shall be provided:

a) in passenger ships:

1) in the spaces above the bulkhead deck, scuppers shall be fitted so as to ensure that such water is rapidly discharged directly overboard

2)

- in ro-ro passenger ships, discharge valves for scuppers, fitted with positive means of closing operable from a position above the bulkhead deck in accordance with the requirements of the International Convention on Load Lines in force, shall be kept open while the ships are at sea
- any operation of valves referred to in the item just above shall be recorded in the log-book

3) in the spaces below the bulkhead deck, the Society may require pumping and drainage facilities to be provided additional to the rules requirements. In such

case, the drainage system shall be sized to remove no less than 125% of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles. The drainage system valves shall be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells shall be of sufficient holding capacity and shall be arranged at the side shell of the ship at a distance from each other of not more than 40 m in each watertight compartment.

b) in cargo ships:

The drainage and pumping arrangements shall be such as to prevent the build-up of free surfaces. In such case, the drainage system shall be sized to remove no less than 125% of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles. The drainage system valves shall be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells shall be of sufficient holding capacity and shall be arranged at the side shell of the ship at a distance from each other of not more than 40 m in each watertight compartment. If this is not possible, the adverse effect upon stability of the added weight and free surface of water shall be taken into account to the extent deemed necessary by the Society in its approval of the stability information. Such information shall be included in the stability information supplied to the master.

5.2 Portable fire extinguishers

5.2.1 Portable fire extinguishers shall be provided at each deck level in each hold or compartment where vehicles are carried, spaced not more than 20 m apart on both sides of the space. At least one portable fire extinguisher shall be located at each access to such a cargo space.

5.2.2 In addition to the provision of 5.2.1, the following fire-extinguishing appliances shall be provided in vehicle, ro-ro and special category spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion:

a) at least three water-fog applicators, and

b) one portable foam applicator unit complying with the provisions of Sec 13, provided that at least two such units are available in the ship for use in such spaces.

Section 13 Fire Safety Systems

1 General

1.1 Application

1.1.1 This Section is applicable to fire safety systems as referred to in the other Sections of this Section.

1.2 Use of toxic extinguishing media

1.2.1 The use of a fire-extinguishing medium which, in the opinion of the Society, either by itself or under expected conditions of use gives off toxic gases, liquids and other substances in such quantities as to endanger persons shall not be permitted.

2 International shore connections

2.1 Engineering specifications

2.1.1 Standard dimensions

Standard dimensions of flanges for the international shore connection shall be in accordance with Table 2.1 (see also Figure 2.1).

Figure 2.1: International shore connection

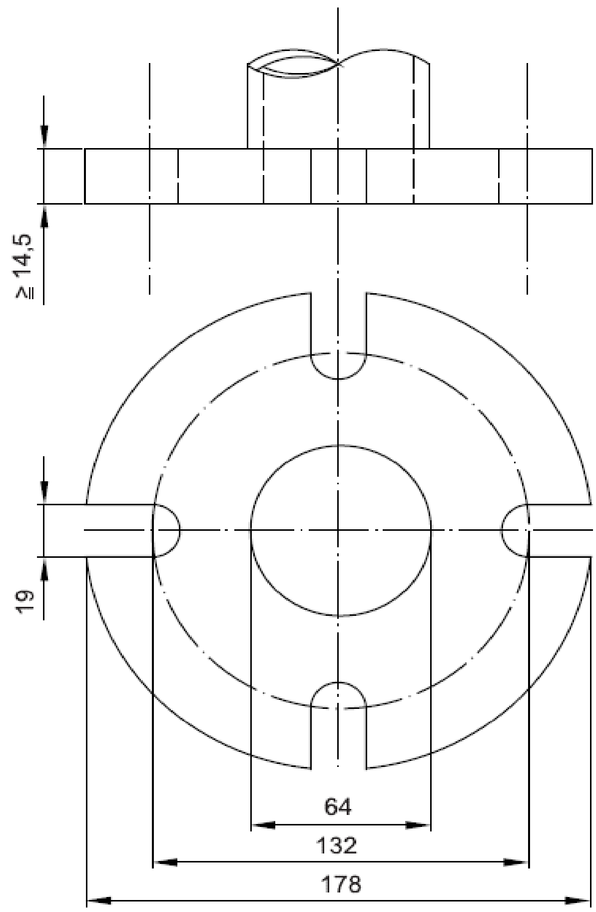


Table 2.1: Standard dimensions

Description	Dimension
Outside diameter	178 mm
Inside diameter	64 mm
Bolt circle diameter	132 mm
Slots in flange	4 holes, 19 mm in diameter spaced equidistantly on a bolt circle of the above diameter, slotted to the flange periphery
Flange thickness	14.5 mm minimum
Bolts and nuts	4, each of 16 mm diameter, 50 mm in length

2.1.2 Materials and accessories

International shore connections shall be of steel or other equivalent material and shall be designed for 1,0 N/mm^2 services. The flange shall have a flat face on one side and, on the other side, it shall be permanently attached to a coupling that will fit the ship's hydrant and hose. The connection shall be kept aboard the ship together with a gasket of any material suitable for 1,0 N/mm^2 services, together with four bolts of 16 mm diameter and 50 mm in length, four 16 mm nuts and eight washers.

3 Fire extinguishers

3.1 Type approval

3.1.1 All fire extinguishers shall be of approved types and designs.

3.2 Engineering specifications

3.2.1 Fire extinguisher

a) Safety requirements

Fire extinguishers containing an extinguishing medium which, in the opinion of the Society, either by itself or under the expected conditions of use gives off toxic gases in such quantities as to endanger persons or which is an ozone depleting substance shall not be permitted.

b) Quantity of medium

1) Each powder or carbon dioxide extinguisher shall have a capacity of at least 5 kg and each foam extinguisher shall have a capacity of at least 9 l. The mass of all portable fire extinguishers shall not exceed 23 kg and they shall have a fire-extinguishing capability at least equivalent to that of a 9 l fluid extinguisher.

2) The Society shall determine the equivalents of fire extinguishers.

3.2.2 Portable foam applicators

A portable foam applicator unit shall consist of a foam nozzle of an inductor type capable of being connected to the fire main by a fire hose, together with a portable tank containing at least 20 *l* of foam-forming liquid and one spare tank of foam making liquid. The nozzle shall be capable of producing effective foam suitable for extinguishing an oil fire, at the rate of at least 1.5 m^3/min.

A water fog applicator might consist of a metal L-shaped pipe, the long limb being about 2 m in length capable of being fitted to a fire hose and the short limb being about 250 mm in length fitted with a fixed water fog nozzle or capable of being fitted with a water spray nozzle.

4 Fixed gas fire-extinguishing systems

4.1 Engineering specifications

4.1.1 General

a) Fire-extinguishing medium

1) Where the quantity of the fire-extinguishing medium is required to protect more than one space, the quantity of medium available need not be more than the largest quantity required for any one space so protected.

2) Where the volume of free air contained in air receivers in any space is such that, if released in such space in the event of fire, such release of air within that space would seriously affect the efficiency of the fixed fire-extinguishing system, the Society shall require the provision of an additional quantity of fire-extinguishing medium.

The volume of starting air receivers, converted to free air volume, shall be added to the gross volume of the machinery space when calculating the necessary quantity of the fire-extinguishing medium. Alternatively, a discharge pipe from the safety valves may be fitted and led directly to the open air.

3) Means shall be provided for the crew to safely check the quantity of the fire-extinguishing medium in the containers.

4) Containers for the storage of fire-extinguishing medium and associated pressure components shall be designed to pressure codes of practice to the satisfaction of the Society having regard to their locations and maximum ambient temperatures expected in service.

b) Installation requirements

1) The piping for the distribution of fire-extinguishing medium shall be arranged and discharge nozzles so positioned that a uniform distribution of the medium is obtained.

In large cargo spaces, at least two distribution pipes are to be provided, one on the fore part, the second at the aft part.

In machinery spaces, the discharge nozzles are to be positioned in the upper and lower parts of these spaces.

2) Except as otherwise permitted by the Society, pressure containers required for the storage of the fire extinguishing medium, other than steam, shall be located outside the protected spaces in accordance with Sec 6, 3.3.

3) The storage of the fire extinguishing medium is not permitted within spaces which may contain air/flammable gas mixtures.

c) System control requirements

1) The necessary pipes for conveying fire-extinguishing medium into the protected spaces shall be provided with control valves so marked as to indicate clearly the space to which the pipes are led. Suitable provision shall be made to prevent inadvertent release of the medium into the space. Where a cargo space fitted with a gas fire-extinguishing system is used as a passenger space, the gas connection shall be blanked during such use. The pipes may pass through accommodation areas provided that they are of substantial thickness and that their tightness is verified with a pressure test, after their installation, at a pressure head not less than 5 N/mm^2. In addition, pipes passing through accommodation areas shall be joined only by welding and shall not be fitted with drains or other openings within such spaces.

The pipes shall not pass through refrigerated spaces.

Control valves are to be capable of local operation.

The open or closed position of control valves is to be indicated.

Means are to be provided in order to permit the blowing through each branch line of the piping system downstream of the master (control) valves.

2) Means shall be provided for automatically giving audible warning of the release of fire-extinguishing medium into any ro-ro spaces and other spaces in which personnel normally work or to which they have access. The pre-discharge alarm shall be automatically activated (e.g. by opening of the release cabinet door). The alarm shall operate for the length of time needed to evacuate the space, but in no case less than 20 seconds before the medium is released.

Where audible alarms are fitted to warn of the release of fire-extinguishing medium into pump rooms, they may be of the pneumatic or electrical type:

- Pneumatically operated alarms

Air operated alarms may be used provided the air supply is clean and dry.

- Eletrically operated alarms

When electrically operated alarms are used, the arrangements are to be such that the electrical actuating mechanism is located outside the pump room except where the alarms are certified intrinsically safe.

Electrically operated alarms are to be supplied with power from the main and an emergency source of power. They are to differ from other signals transmitted to the protected space.

3) The means of control of any fixed gas fire-extinguishing system shall be readily accessible, simple to operate and shall be grouped together in as few locations as possible at positions not likely to be cut off by a fire in a protected space. At each location there shall be clear instructions relating to the operation of the system having regard to the safety of personnel.

4) Automatic release of fire-extinguishing medium shall not be permitted, except as permitted by the Society.

4.1.2 Carbon dioxide systems - General

a) Quantity of fire-extinguishing medium

1) For cargo spaces the quantity of carbon dioxide available shall, unless otherwise provided, be sufficient to give a minimum volume of free gas equal to 30% of the gross volume of the largest cargo space to be protected in the ship.

2) For machinery spaces the quantity of carbon dioxide carried shall be sufficient to give a minimum volume of free gas equal to the larger of the following volumes, either:

- 40% of the gross volume of the largest machinery space so protected, the volume to exclude that part of the casing above the level at which the horizontal area of the casing is 40% or less of the horizontal area of the space concerned taken midway between the tank top and the lowest part of the casing, or
- 35% of the gross volume of the largest machinery space protected, including the casing.

In the calculation of 35% of the above-mentioned volume, the net volume of the funnel shall 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 inter-position of closing means.

3) The percentages specified in item 2) above may be reduced to 35% and 30%, respectively, for cargo ships of less than 2000 gross tonnage provided that, where two or more machinery spaces are not entirely separate, they shall be considered as forming one space.

4) For the purpose of this item the volume of free carbon dioxide shall be calculated at 0,56 m3/kg.

5) For machinery spaces, the fixed piping system shall be such that 85% of the gas can be discharged into the space within 2 minutes.

b) Controls

1) Carbon dioxide systems shall comply with the following requirements:

- two separate controls shall be provided for releasing carbon dioxide into a protected space and to ensure the activation of the alarm. One control shall be used for opening the valve of the piping which conveys the gas into the protected space and a second control shall be used to discharge the gas from its storage containers, and
- the two controls shall be located inside a release box clearly identified for the particular space. If the box containing the controls is to be locked, a key to the box shall be in a break-glass-type enclosure conspicuously located adjacent to the box.
-

Table 4.1: Minimum wall thickness for steel pipes for CO_2 fire-extinguishing systems

External diameter (mm)	Minimum wall thickness (mm)	
	Between bottles and master valves	Between master valves and 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

4.1.3 High-pressure carbon dioxide systems

a) The system is to be designed for an ambient temperature range of 0°C/55°C, as a rule.

b) Containers for the storage of the fire-extinguishing medium are to be designed and tested in accordance with the relevant requirements of Chapter 1.

c) The filling ratio of carbon dioxide bottles is to be normally 0.67 kg/l, or less, of the total internal volume;

however, for bottles to be fitted in ships which are to operate solely outside the tropical zone, the filling ratio may be 0.75 kg/l.

d) Piping and accessories are to generally satisfy the relevant requirements of Chapter 1.

e) For systems where carbon dioxide is stored at ambient temperature, the thickness of steel pipes is not to be less than the values given in Table 4.1.

Slightly smaller thicknesses may be accepted provided they comply with national standards.

The thickness of threaded pipes is to be measured at the bottom of the thread.

f) Pipes are to be appropriately protected against corrosion.

Steel pipes are to be, at least, zinc or paint coated, except those fitted in machinery spaces, with the reservation of the Society's acceptance.

g) After mounting onboard, and in complement to tests and inspections at the Manufacturer's workshop, as per requirements of Chapter 1, carbon dioxide pipes and their accessories are to undergo the following tests:

- pipe lengths between bottles and master valves:

hydraulic test, at the workshop or on board, at 128 bar. When the hydraulic test is carried out at the workshop, at least test with inert gas or air, at 7 bar, is to be carried out on board.

- pipe lengths between master valves and nozzles:

test on board with inert gas or air, at 7 bar. The master valves are to undergo a hydraulic test at 128 bar.

4.1.4 Low-pressure carbon dioxide systems

When carbon dioxide, instead of being contained in nonrefrigerated high pressure bottles, is contained in refrigerated low pressure vessels, in addition to the requirements in 4.1.2 the following are to be complied with.

a) General

Except where different requirements are given in this item, the requirements of 4.1.3 for systems with carbon dioxide contained in high pressure bottles are generally to be complied with.

b) Vessels and associated devices

1) The rated amount of liquid carbon dioxide is to be stored in vessels under the working pressure in the range of 1.8 MPa to 2.2 MPa. The normal liquid charge in the container is to be limited to provide sufficient vapour space to allow for expansion of the liquid under the maximum storage temperatures that can be obtained corresponding to the setting of the pressure relief valves, but is not to exceed 95% of the volumetric capacity of the container.

2) The vessels are to be designed, constructed and tested in accordance with the requirements of Ch 1Sec3. For this purpose the design pressure is to be taken not less than the relief valve setting. In addition, for each vessel, provision is to be made for:

   - a pressure gauge
   - a high pressure alarm: not more than the setting of the relief valve
   - a low pressure alarm: not less than 1.8 MPa
   - branch pipes with stop valves for filling the vessel
   - discharge pipes
   - a liquid CO_2 level indicator, fitted on the vessel
   - two safety relief valves arranged so that either valve can be shut off while the other is connected to the vessel. The setting of the relief valves is to be not less than 1.1 times the working pressure. The capacity of each valve is to be such that the vapours generated due to fire can be discharged with a pressure rise not more than 20% above the setting pressure. The discharge from the safety valves is to be led to the open.

3) The vessels and outgoing pipes permanently filled with carbon dioxide are to have thermal insulation preventing the operation of the safety valve for 24 hours after de-energising the plant, at ambient temperature of 45°C and an initial

pressure equal to the starting pressure of the refrigeration unit. The insulating materials and their liners are to be to the satisfaction of the Society, bearing in mind, in particular, their fire resistance and mechanical properties, as well as protection against penetration of water vapours.

c) Refrigerating plant

1) The vessels are to be serviced by two automated completely independent refrigerating units solely intended for this purpose, each comprising a compressor and the associated prime mover, evaporator and condenser.

2) The refrigerating plant is to comply with the relevant requirements of Ch.1, Sec 13. The refrigerating capacity and the automatic control of each unit are to be such as to maintain the required temperature under conditions of continuous operation for 24 hours at a sea temperature up to 32°C and ambient air temperature up to 45°C.

3) In the event of failure of either one of the refrigerating units, the other is to be actuated automatically.

Provision is to be made for local manual control of the refrigerating plant.

4) Each electrical refrigerating unit is to be supplied from the main switchboard busbars by a separate feeder.

5) The cooling water supply to the refrigerating plant (where required) is to be provided from at least two circulating pumps, one of which being used as a standby. The standby pump may be a pump used for other services so long as its use for cooling would not interfere with any other essential service of the ship. Cooling water is to be taken from not less than two sea connections, preferably one port and one starboard.

d) Pipes, valves and associated fittings

1) The pipes, valves and fittings are to be in accordance with the requirements of Sec 11 for a design pressure not less than the design pressure of the CO_2 vessels.

2) Safety relief devices are to be provided in each section of pipe that may be isolated by block valves and in which there could be a build up of pressure in excess of the design pressure of any of the components.

3) The piping system is to be designed in such a way that the CO_2 flows through in liquid phase up to the discharge nozzles. For this purpose, the pressure at the nozzles is to be not less than 1 MPa.

e) Control of fire-extinguishing system operation The machinery alarm system is to be equipped with audible and visual alarms activated when:

1) the pressure in the vessels reaches the low and the high values according to item b) 2) above

2) any one of the refrigerating units fails to operate

3) the lowest permissible level of the liquid in the vessels is reached.

f) Release control

1) The release of CO_2 is to be initiated manually.

2) If a device is provided which automatically regulates the discharge of the rated quantity of carbon dioxide into the protected spaces, it is also to be possible to regulate the discharge manually.

3) If the system serves more than one space, means for control of discharge quantities of CO_2 are to be provided, e.g. automatic timer or accurate level indicators located at the control positions or positions.

g) Testing

1) The pipes, valves and fittings and assembled system are to be tested to the satisfaction of the Society.

2) The pipes from the vessels to the release valves on the distribution manifold are to be subjected to a pressure test to not less than 1.5 times the set pressure of the safety relief valves.

3) The pipes from the release valves on the distribution manifold to the nozzles are to be tested for tightness and free flow of CO_2, after having been assembled on board.

4) After having been fitted on board, the refrigerating plant is to be checked for its proper operation.

5) If deemed necessary by the Society, a discharge test may be required to check the fulfillment of the requirements of item d) 3) above.

4.2 Equivalent fixed gas fire-extinguishing systems

4.2.1 Fixed gas fire-extinguishing systems equivalent to those specified in [4.1] are to be specially considered by the Society.

5 Fixed foam fire-extinguishing systems

5.1 Engineering specifications

5.1.1 General

Fixed foam fire-extinguishing systems shall be capable of generating foam suitable for extinguishing oil fires.

5.1.2 Fixed high-expansion foam fire-extinguishing systems

a) Quantity and performance of foam concentrates

1) The foam concentrates of high-expansion foam fire extinguishing systems shall be approved by the Society.

2) Any required fixed high-expansion foam system in machinery spaces shall be capable of rapidly discharging through fixed discharge outlets a quantity of foam sufficient to fill the greatest space to be protected at a rate of at least 1 m in depth per minute.

The quantity of foam-forming liquid available shall be sufficient to produce a volume of foam equal to five times the volume of the largest space to be protected.

The expansion ratio of the foam shall not exceed 1000 to 1.

3) The Society may permit alternative arrangements and discharge rates provided that it is satisfied that equivalent protection is achieved.

4) Any required fixed high-expansion foam system in vehicle spaces and in ro-ro cargo spaces is to be capable of protecting all the deck parts of the space and also any platforms. The system shall be capable of discharging a quantity of foam sufficient to:

- fill the greatest space to be protected at a rate of 1 metre in depth per minute, referring to the maximum horizontal area of the space itself
- fill the whole space to be protected within 5 minutes.

A quantity of foam-forming liquid sufficient to produce a volume of foam not less than 5 times the volume of the largest space to be protected shall be available on board.

b) Installation requirements

1) Supply ducts for delivering foam, air intakes to the foam generator and the number of foam-producing units shall, in the opinion of the Society, be such as will provide effective foam production and distribution.

2) The arrangement of the foam generator delivery ducting shall be such that a fire in the protected space will not affect the foam generating equipment. If the foam-generators are located adjacent to the protected space, foam delivery ducts shall be installed to allow at least 450 mm of separation between the generators and the protected space. The foam delivery ducts shall be constructed of steel having a thickness of not less than 5 mm. In addition, stainless steel dampers (single or multi-bladed) with a thickness of not less than 3 mm shall be installed at the openings in the boundary bulkheads or decks between the foam generators and the protected space. The dampers shall be automatically operated (electrically, pneumatically or hydraulically) by means of remote control of the foam generator related to them.

3) The foam generator, its sources of power supply, foam-forming liquid and means of controlling the system shall be readily accessible and simple to operate and shall be grouped in as few locations as possible at positions not likely to be cut off by a fire in the protected space.

5.1.3 Fixed low-expansion foam fire-extinguishing systems

a) Quantity and foam concentrates

1) The foam concentrates of low-expansion foam fire extinguishing systems shall be approved by the Society.

2) The system shall be capable of discharging through fixed discharge outlets in not more than five minutes a quantity of foam sufficient to cover to a depth of

150 mm the largest single area over which oil fuel is liable to spread. The expansion ratio of the foam shall not exceed 12 to 1.

b) Installation requirements

1) Means shall be provided for the effective distribution of the foam through a permanent system of piping and control valves or cocks to suitable discharge outlets, and for the foam to be effectively directed by fixed sprayers onto other main fire hazards in the protected space. The means for effective distribution of the foam shall be proven acceptable to the Society through calculation or by testing.

2) The means of control of any such systems shall be readily accessible and simple to operate and shall be grouped together in as few locations as possible at positions not likely to be cut off by a fire in the protected space.

6 Fixed pressure water-spraying and water-mist fire-extinguishing systems

6.1 Engineering specifications

6.1.1 Fixed pressure water-spraying fire extinguishing systems

a) Nozzles and pumps

1) The number and arrangement of the nozzles of any required fixed pressure water-spraying fire-extinguishing system in machinery spaces shall be to the satisfaction of the Society and shall be such as to ensure an effective average distribution of water of at least 5 l/m^2/minute in the spaces to be protected.

Where increased application rates are considered necessary, these shall be to the satisfaction of the Society.

2) The number and arrangement of the nozzles of any required fixed pressure water-spraying fire-extinguishing system in vehicle spaces and ro-ro cargo spaces are to be such as to ensure an effective average distribution of water of at least:

- 3.5 $l/(m^2 min)$ for spaces having a height not exceeding 2.5 m
- 5 $l/(m^2 min)$ for spaces having a height more than 2.5 m.

3) Precautions shall be taken to prevent the nozzles from becoming clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.

4) In machinery spaces the pump shall be capable of simultaneously supplying at the necessary pressure all sections of the system in any one compartment to be protected.

In vehicle spaces and ro-ro cargo spaces the pump or pumps shall be capable of providing simultaneously, at all times, a sufficient supply of water at the required pressure to all nozzles of the system or at least to those of two sections.

5) The pump may be driven by independent internal combustion machinery, but, if it is dependent upon power being supplied from the emergency generator fitted in compliance with the provisions of appropriate rules, the generator shall be so arranged as to start automatically in case of main power failure so that power

for the pump required by the previous item 4) is immediately available. The independent internal combustion machinery for driving the pump shall be so situated that a fire in the protected space or spaces will not affect the air supply to the machinery.

b) Installation requirements for machinery spaces

1) Nozzles shall be fitted above bilges, tank tops and other areas over which oil fuel is liable to spread and also above other specific fire hazards in the machinery spaces.

2) The system may be divided into sections, the distribution valves of which shall be operated from easily accessible positions outside the spaces to be protected so as not to be readily cut off by a fire in the protected space.

3) The pump and its controls shall be installed outside the space or spaces to be protected. It shall not be possible for a fire in the space or spaces protected by the water-spraying system to put the system out of action.

c) Installation requirements for vehicle spaces and ro-ro cargo spaces

The system is to protect the whole space but may be subdivided into sections. Each section is to be not less than 20 m long. These sections are, as a rule, to have the same width as the space width except for those ships where the space is subdivided by A class longitudinal fire divisions forming the boundaries of stairways or other spaces, for which the section width may be reduced in proportion. An even water distribution to the whole space to be protected is to be ensured. The distribution valves for the system are to be located in an easily accessible position, adjacent to but outside the space to be protected, which will not readily be cut off by a fire within the space. Direct access to the distribution valves from the space and from outside the space is to be provided. Adequate ventilation means is to be fitted in the space containing the distribution valves. The water supply to the system is to be provided by one or more independent pumps which are not the required ship's fire pumps or other pumps intended for services essential for safety and navigation. In any case, the required ship's fire pumps are to be connected to the fire-extinguishing system of the space to be protected by manually lockable non-return valves which will prevent a backflow from the pressure water-spraying system to the fire main.

d) System control requirements

For machinery spaces, the system shall be kept charged at the necessary pressure and the pump supplying the water for the system shall be put automatically into action by a pressure drop in the system.

For vehicle spaces and ro-ro cargo spaces the pump or pumps are to be capable of being brought into operation by remote control from the same position at which the distribution valves are located.

6.1.2 Equivalent water-mist fire-extinguishing systems

Water-mist fire-extinguishing systems for machinery spaces and cargo pump rooms shall be approved by the Society.

7 Automatic sprinkler, fire detection and fire alarm systems

7.1 Engineering specifications

7.1.1 General

a) Type of sprinkler systems

The automatic sprinkler systems shall be of the wet pipe type, but small exposed sections may be of the dry pipe type where, in the opinion of the Society, this is a necessary precaution.

b) Automatic sprinkler systems equivalent to those specified in 7.1.2 to 7.1.4 shall be approved by the Society.

7.1.2 Sources of power supply

a) Passenger ships

There shall be not less than two sources of power supply for the sea water pump and automatic alarm and detection system. Where the sources of power for the pump are electrical, these shall be a main generator and an emergency source of power. One supply for the pump shall be taken from the main switchboard, and one from the emergency switchboard by separate feeders reserved solely for that purpose. The feeders shall be so arranged as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk except in so far as it is necessary to reach the appropriate switchboards, and shall be run to an automatic change-over switch situated near the sprinkler pump. This switch shall permit the supply of power from the main switchboard so long as a supply is available there from, and be so designed that upon failure of that supply it will automatically change over to the supply from the emergency switchboard. The switches on the main switchboard and the emergency switchboard shall be clearly labelled and normally kept closed. No other switch shall be permitted in the feeders concerned. One of the sources of power supply for the alarm and detection system shall be an emergency source. Where one of the sources of power for the pump is an internal combustion engine it shall, in addition to complying with the provisions of item c) of 7.1.4, be so situated that a fire in any protected space will not affect the air supply to the machinery.

b) Cargo ships

There shall be not less than two sources of power supply for the sea water pump and automatic alarm and detection system. If the pump is electrically driven, it shall be connected to the main source of electrical power, which shall be capable of being supplied by at least two generators.

The feeders shall be so arranged as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk except in so far as it is necessary to reach the appropriate switchboards. One of the sources of power supply for the alarm and detection system shall be an emergency source. Where one of the sources of power for the pump is an internal combustion engine, it shall, in addition to complying with the provisions of item c) of 7.1.4, be so situated that a fire in any protected space will not affect the air supply to the machinery.

7.1.3 Component requirements

a) Sprinklers

1) The sprinklers shall be resistant to corrosion by the marine atmosphere. In accommodation and service spaces the sprinklers shall come into operation within the temperature range from 68°C to 79°C, except that in locations such as drying rooms, where high ambient temperatures might be expected, the operating temperature may be increased by not more than 30°C above the maximum deckhead temperature.

b) Pressure tanks

1) A pressure tank having a volume equal to at least twice that of the charge of water specified in this item shall be provided. The tank shall contain a standing charge of fresh water, equivalent to the amount of water which would be discharged in one minute by the pump referred to in item c) 2) below, and the arrangements shall be provided for maintaining an air pressure in the tank such as to ensure that where the standing charge of fresh water in the tank has been used the pressure will be not less than the working pressure of the sprinkler, plus the pressure exerted by a head of water measured from the bottom of the tank to the highest sprinkler in the system.

Suitable means of replenishing the air under pressure and of replenishing the fresh water charge in the tank shall be provided. A glass gauge shall be provided to indicate the correct level of the water in the tank.

The tank is to be designed and built in compliance with the requirements for pressure vessels given in Ch 1, Sec 3.

2) Means shall be provided to prevent the passage of sea water into the tank.

c) Sprinkler pumps

1) An independent power pump shall be provided solely for the purpose of continuing automatically the discharge of water from the sprinklers. The pump shall be brought into action automatically by the pressure drop in the system before the standing fresh water charge in the pressure tank is completely exhausted.

2) The pump and the piping system shall be capable of maintaining the necessary pressure at the level of the highest sprinkler to ensure a continuous output of water sufficient for the simultaneous coverage of a minimum area of 280 m^2 at the application rate specified in item b) 3) of 7.1.5. The hydraulic capability of the system shall be confirmed by the review of hydraulic calculations, followed by a test of the system, if deemed necessary by the Society.

3) The pump shall have fitted on the delivery side a test valve with a short open-ended discharge pipe. The effective area through the valve and pipe shall be adequate to permit the release of the required pump output while maintaining the pressure in the system specified in item b) 1) above.

7.1.4 Installation requirements

a) General

Any parts of the system which may be subjected to freezing temperatures in service shall be suitably protected against freezing.

b) Piping arrangements

1) Sprinklers shall be grouped into separate sections, each of which shall contain not more than 200 sprinklers. In passenger ships, any section of sprinklers shall not serve more than two decks and shall not be situated in more than one main vertical zone. However, the Society may permit such a section of sprinklers to serve more than two decks or be situated in more than one main vertical zone, if it is satisfied that the protection of the ship against fire will not thereby be reduced.

Sprinkler heads installed to fulfill the provisions of Sec 5, 3.2.3 are not required to be solely dedicated to the windows and side scuttles they are to protect, provided that the sprinkler heads protecting the room and having a spraying density of 5 l/ (m^2 min) are arranged such that the window or side scuttle is covered with the same spraying density and the relevant area is considered in the calculation as per 7.1.5.

2) Each section of sprinklers shall be capable of being isolated by one stop-valve only. The stop-valve in each section shall be readily accessible in a location outside of the associated section or in cabinets within stairway enclosures. The valve's location shall be clearly and permanently indicated. Means shall be provided to prevent the operation of the stop valves by any unauthorized person.

3) A test valve shall be provided for testing the automatic alarm for each section of sprinklers by a discharge of water equivalent to the operation of one sprinkler. The test valve for each section shall be situated near the stop-valve for that section.

4) The sprinkler system shall have a connection from the ship's fire main by way of a lockable screw-down non-return valve at the connection which will prevent a backflow from the sprinkler system to the fire main.

The automatic sprinkler fire detection and fire alarm system shall be an independent unit and therefore no other piping system shall be connected to it, except for the following:

- connections for feeding the system from shore side sources, fitted with adjacent stop valves and non-return valves
- connection from the fire main as required above.

The valves on the shore filling connection and on the fire main connection shall be fitted with clear and permanent labels indicating their service. These valves shall be capable of being locked in the "closed" position.

5) A gauge indicating the pressure in the system shall be provided at each section stop-valve and at a central station.

6) The sea inlet to the pump shall, wherever possible, be in the space containing the pump and shall be so arranged that when the ship is afloat it will not be necessary to shut off the supply of sea water to the pump for any purpose other than the inspection or repair of the pump.

c) Location of systems

The sprinkler pump and tank shall be situated in a position reasonably remote from any machinery space of category A and shall not be situated in any space required to be protected by the sprinkler system.

7.1.5 System control requirements

a) Ready availability

1) Any required automatic sprinkler, fire detection and fire alarm system shall be capable of immediate operation at all times and no action by the crew shall be necessary to set it in operation.

2) The automatic sprinkler system shall be kept charged at the necessary pressure and shall have provision for a continuous supply of water as required in this Section.

b) Alarm and indication

1) Each section of sprinklers shall include means for giving a visual and audible alarm signal automatically at one or more indicating units whenever any sprinkler comes into operation. Such alarm systems shall be such as to indicate if any fault occurs in the system. Such units shall indicate in which section served by the system a fire has occurred and shall be centralized on the navigation bridge or in the continuously- manned central control station and, in addition, visible and audible alarms from the unit shall also be placed in a position other than on the aforementioned spaces to ensure that the indication of fire is immediately received by the crew.

2) Switches shall be provided at one of the indicating positions referred to in the previous item 1) which will enable the alarm and the indicators for each section of sprinklers to be tested.

3) Sprinklers shall be placed in an overhead position and spaced in a suitable pattern to maintain an average application rate of not less than 5 l/m^2/minute over the nominal area covered by the sprinklers.

However, the Society may permit the use of sprinklers providing such an alternative amount of water suitably distributed as has been shown, to the satisfaction of the Society, to be not less effective.

4) A list or plan shall be displayed at each indicating unit showing the spaces covered and the location of the zone in respect of each section. Suitable instructions for testing and maintenance shall be available.

c) Testing

Means shall be provided for testing the automatic operation of the pump on reduction of pressure in the system.

8 Fixed fire detection and fire alarm systems

8.1 Engineering specifications

8.1.1 General requirements

a) Any required fixed fire detection and fire alarm system with manually operated call points shall be capable of immediate operation at all times.

b) The fixed fire detection and fire alarm system shall not be used for any other purpose, except that closing of fire doors and similar functions may be permitted at the control panel.

c) The system and equipment shall be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships.

d) Fixed fire detection and fire alarm systems with a zone address identification capability shall be so arranged that:

1) means are provided to ensure that any fault (e.g. power break, short circuit, earth, etc.) occurring in the loop will not render the whole loop ineffective

Note 1: Loop means an electrical circuit linking detectors of various sections in a sequence and connected (input and output) to the indicating unit(s).

2) all arrangements are made to enable the initial configuration of the system to be restored in the event of failure (e.g. electrical, electronic, informatics, etc.)

3) the first initiated fire alarm will not prevent any other detector from initiating further fire alarms, and

4) no loop will pass through a space twice. When this is not practical (e.g. for large public spaces), the part of the loop which by necessity passes through the space for a second time shall be installed at the maximum possible distance from the other parts of the loop.

8.1.2 Sources of power supply

There shall be not less than two sources of power supply for the electrical equipment used in the operation of the fixed fire detection and fire alarm system, one of which shall be an emergency source. The supply shall be provided by separate feeders reserved solely for that purpose. Such feeders shall run to an automatic change-over switch situated in, or adjacent to, the control panel for the fire detection system.

The main (respective emergency) feeder shall run from the main (respective emergency) switchboard to the changeover switch without passing through any other distributing switchboard.

8.1.3 Component requirements

a) Detectors

1) Detectors shall be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered by the Society provided that they are no less sensitive than such detectors. Flame detectors shall only be used in addition to smoke or heat detectors.

2) Smoke detectors required in stairways, corridors and escape routes within accommodation spaces shall be certified to operate before the smoke density exceeds 12,5% obscuration per metre, but not until the smoke density exceeds 2% obscuration per metre. Smoke detectors to be installed in other spaces shall operate within sensitivity limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

3) Heat detectors shall be certified to operate before the temperature exceeds 78°C but not until the temperature exceeds 54°C, when the temperature is raised to those limits at a rate less than 1°C per minute. At higher rates of temperature rise, the heat detector shall operate within temperature limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity.

4) The operation temperature of heat detectors in drying rooms and similar spaces of a normal high ambient temperature may be up to 130°C, and up to 140°C in saunas.

5) All detectors shall be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.

8.1.4 Installation requirements

a) Sections

1) Detectors and manually operated call points shall be grouped into sections.

Note 1: Section means group of fire detectors and manually operated call points as shown in the indicating unit(s) required in item a) 3) of 8.1.5.

2) A section of fire detectors which covers a control station, a service space or an accommodation space shall not include a machinery space of category A. For fixed fire detection and fire alarm systems with remotely and individually identifiable fire detectors, a loop covering sections of fire detectors in accommodation, service spaces and control stations shall not include sections of fire detectors in machinery spaces of category A.

3) Where the fixed fire detection and fire alarm system does not include means of remotely identifying each detector individually, no section covering more than one deck within accommodation spaces, service spaces and control stations shall normally be permitted except a section which covers an enclosed stairway.

In order to avoid delay in identifying the source of fire, the number of enclosed spaces included in each section shall be limited as determined by the Society. In no case shall more than fifty enclosed spaces be permitted in any section. If the system is fitted with remotely and individually identifiable fire detectors, the sections may cover several decks and serve any number of enclosed spaces.

4) In passenger ships, if there is no fixed fire detection and fire alarm system capable of remotely and individually identifying each detector, a section of detectors shall not serve spaces on both sides of the ship nor on more than one deck and neither shall it be situated in more than one main vertical zone except that the same section of detectors may serve spaces on more than one deck if those spaces are located in the fore or aft end of the ship or if they protect common spaces on different decks (e.g. fan rooms, galleys, public spaces, etc.). In ships of less than 20 m in breadth, the same section of detectors may serve spaces on both sides of the ship. In passenger ships fitted with individually identifiable fire detectors, a section may serve spaces on both sides of the ship and on several decks, but shall not be situated in more than one main vertical zone.

b) Position of detectors

1) Detectors shall be located for optimum performance.

Positions near beams and ventilation ducts or other positions where patterns of air flow could adversely affect performance and positions where impact or physical damage is likely shall be avoided.

Detectors which are located on the overhead shall be a minimum distance of 0,5 m away from bulkheads, except in corridors, lockers and stairways.

2) The maximum spacing of detectors shall be in accordance with Table 8.1. The Society may require or permit different spacing to that specified in Tab 8.1, if based upon test data which demonstrate the characteristics of the detectors.

c) Arrangement of electric wiring

1) Electrical wiring which forms part of the system shall be so arranged as to avoid galleys, machinery spaces of category A and other enclosed spaces of high fire risk except where it is necessary to provide for fire detection or fire alarms in such spaces or to connect to the appropriate power supply.

2) A loop of fire detection systems with a zone address identification capability shall not be damaged at more than one point by a fire.

Table 8.1: Spacing of detectors

Type of detector	Maximum floor area per detector	Maximum distance apart between centres	Maximum distance away from bulkheads
Heat	37 m^2	9 m	4.5 m
Smoke	74 m^2	11 m	5.5 m

8.1.5 System control requirements

a) Visual and audible fire signals

1) The activation of any detector or manually operated call point shall initiate a visual and audible fire signal at the control panel and indicating units. If the signals have not received attention within two minutes, an audible alarm shall be automatically sounded throughout the crew accommodation and service

spaces, control stations and machinery spaces of category A. This alarm sounder system need not be an integral part of the detection system.

2) The control panel shall be located on the navigation bridge or in the continuously manned central control station.

3) Indicating units shall, as a minimum, denote the section in which a detector has been activated or manually operated call point has been operated. At least one unit shall be so located that it is easily accessible to responsible members of the crew at all times. One indicating unit shall be located on the navigation bridge if the control panel is located in the main fire control station.

4) Clear information shall be displayed on or adjacent to each indicating unit about the spaces covered and the location of the sections.

5) Power supplies and electric circuits necessary for the operation of the system shall be monitored for loss of power or fault conditions as appropriate. Occurrence of a fault condition shall initiate a visual and audible fault signal at the control panel which shall be distinct from a fire signal.

b) Testing

Suitable instructions and component spares for testing and maintenance shall be provided.

9 Sample extraction smoke detection systems

9.1 Engineering specifications

9.1.1 General requirements

a) Wherever in the text of sub-section 9 the word "system" appears, it shall mean "sample extraction smoke detection system".

b) Any required system shall be capable of continuous operation at all times except that systems operating on a sequential scanning principle may be accepted, provided that the interval between scanning the same position twice gives an overall response time to the satisfaction of the Society.

c) The system shall be designed, constructed and installed so as to prevent the leakage of any toxic or flammable substances or fire-extinguishing media into any accommodation and service space, control station or machinery space.

d) The system and equipment shall be suitably designed to withstand supply voltage variations and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships and to avoid the possibility of ignition of a flammable gas-air mixture.

e) The system shall be of a type that can be tested for correct operation and restored to normal surveillance without the renewal of any component.

f) An alternative power supply for the electrical equipment used in the operation of the system shall be provided.

9.1.2 Component requirements

a) The sensing unit shall be certified to operate before the smoke density within the sensing chamber exceeds 6,65% obscuration per metre.

b) Duplicate sample extraction fans shall be provided. The fans shall be of sufficient capacity to operate under normal ventilation conditions in the protected area and shall give an overall response time to the satisfaction of the Society.

c) The control panel shall permit observation of smoke in the individual sampling pipe.

d) Means shall be provided to monitor the airflow through the sampling pipes so designed as to ensure that, as far as practicable, equal quantities are extracted from each interconnected accumulator.

e) Sampling pipes shall be a minimum of 12 mm internal diameter except when used in conjunction with fixed gas fire-extinguishing systems when the minimum size of pipe shall be sufficient to permit the fire-extinguishing gas to be discharged within the appropriate time.

f) Sampling pipes shall be provided with an arrangement for periodically purging with compressed air.

9.1.3 Installation requirements

a) Smoke accumulators

1) At least one smoke accumulator shall be located in every enclosed space for which smoke detection is required. However, where a space is designed to carry oil or refrigerated cargo alternatively with cargoes for which a smoke sampling system is required, means may be provided to isolate the smoke accumulators in such compartments for the system. Such means shall be to the satisfaction of the Society.

2) Smoke accumulators shall be located for optimum performance and shall be spaced so that no part of the overhead deck area is more than 12 m measured horizontally from an accumulator. Where systems are used in spaces which may be mechanically ventilated, the position of the smoke accumulators shall be considered having regard to the effects of ventilation.

3) Smoke accumulators shall be positioned where impact or physical damage is unlikely to occur.

4) Not more than four accumulators shall be connected to each sampling point.

5) Smoke accumulators from more than one enclosed space shall not be connected to the same sampling point.

b) Sampling pipes

1) The sampling pipe arrangements shall be such that the location of the fire can be readily identified.

2) Sampling pipes shall be self-draining and suitably protected from impact or damage from cargo working.

9.1.4 System control requirements

a) Visual and audible fire signals

1) The control panel shall be located on the navigation bridge or in the continuously manned central control station.

2) Clear information shall be displayed on, or adjacent to, the control panel designating the spaces covered.

3) The detection of smoke or other products of combustion shall initiate a visual and audible signal at the control panel and the navigation bridge or continuously manned central control station.

4) Power supplies necessary for the operation of the system shall be monitored for loss of power. Any loss of power shall initiate a visual and audible signal at the control panel and the navigation bridge which shall be distinct from a signal indicating smoke detection.

b) Testing

Suitable instructions and component spares shall be provided for the testing and maintenance of the system.

10 Low-location lighting systems

10.1 Application

10.1.1 This Article details the specifications for low-location lighting systems as required by Sec 8.

10.2 Engineering specification

10.2.1 General requirements

Any required low-location lighting systems shall be approved by the Society based on the guidelines developed by the Organization, or to an international standard acceptable to the Society.

Note 1: Refer to the Guidelines for the evaluation, testing and application of low-location lighting on passenger ships as adopted by the organization by resolution A.752 (18).

Note 2: Refer to the Recommendations by the International Organization for Standardization, in particular, publication ISO 15370:2001 on Low-location lighting on passenger ships.

11 Fixed emergency fire pumps

11.1 Engineering specifications

11.1.1 Type of emergency fire pumps

The emergency fire pump shall be a fixed independently driven power-operated pump.

11.1.2 Component requirements

a) Emergency fire pumps

1) Capacity of the pump

The capacity of the pump shall not be less than 40% of the total capacity of the fire pumps required by Sec 6, 1.3.4 and in any case not less than the following:

- for passenger ships of less than 1000 gross tonnage and for cargo ships of 2000 gross tonnage and upwards: 25 m^3/h, and
- for cargo ships of less than 2000 gross tonnage: 15 m3/h.

The emergency pump is to be capable of supplying two jets of water to the satisfaction of the Society and the amount of water needed for any fixed fire extinguishing system provided to protect the space where the main fire pumps are located.

2) Pressure at hydrants

When the pump is delivering the quantity of water required by item 1) above, the pressure at any hydrants shall be not less than the minimum pressure required in Sec 6, 1.2.6.

3) Suction heads

The total suction head and the net positive suction head of the pump shall be determined having due regard to the requirements of Sec 6 and the present Article on the pump capacity and on the hydrant pressure under all conditions of list, trim, roll and pitch likely to be encountered in service. The ballast condition of a ship on entering or leaving a dry dock need not be considered a service condition.

4) Arrangement of the sea suction of the emergency fire pump

- The sea suction for the pump is to be fitted at a safe depth below the waterline at any draught under all trim and heeling conditions; the ballast condition of a ship on entering or leaving a dry dock need not be considered a service condition.

The emergency fire pump is to be of the self-priming type. The location of the pump is to be such that it is capable of pumping at any draught under all trim and heeling conditions.

The sea valve is to be capable of being operated from a position near the pump.

- Where it is found necessary to locate the emergency fire pump sea suction in the space containing the main fire pumps, the sea valve is to be operable from a readily accessible position not likely to be affected by a fire in the space containing the main fire pumps.

b) Diesel engines and fuel tank

1) Starting of diesel engine

Any diesel-driven power source for the pump shall be capable of being readily started in its cold condition down to the temperature of 0°C by hand (manual) cranking. If this is impracticable, or if lower temperatures are likely to be encountered, consideration shall be given to the provision and maintenance of the heating arrangement acceptable to the Society so that ready starting will be assured. If hand (manual) starting is impracticable, the Society may permit other means of starting. These means shall be such as to enable the diesel-driven power source to be started at least six times within a period of 30 minutes and at least twice within the first 10 minutes.

2) Fuel tank capacity

Any service fuel tank shall contain sufficient fuel to enable the pump to run on full load for at least 3 hours and sufficient reserves of fuel shall be available outside the machinery space of category A to enable the pump to be run on full load for an additional 15 hours.

c) Prime mover and source of power of the emergency fire pump

1) The emergency fire pump and its prime mover are to be to the satisfaction of the Society.

2) The emergency fire pump prime mover is to be so arranged that an immediate start is possible under all prevailing temperature conditions. Diesel engines exceeding 15 kW are to be equipped with an approved auxiliary starting device, e.g. starting battery, independent hydraulic system or independent starting air system, having a capacity sufficient for at least six starts of the fire emergency pump. For diesel engines of 15 kW and smaller, manual means of starting are sufficient.

3) For the operation of the emergency fire pump, fuel is to be available from outside the main machinery space for at least 18h operation.

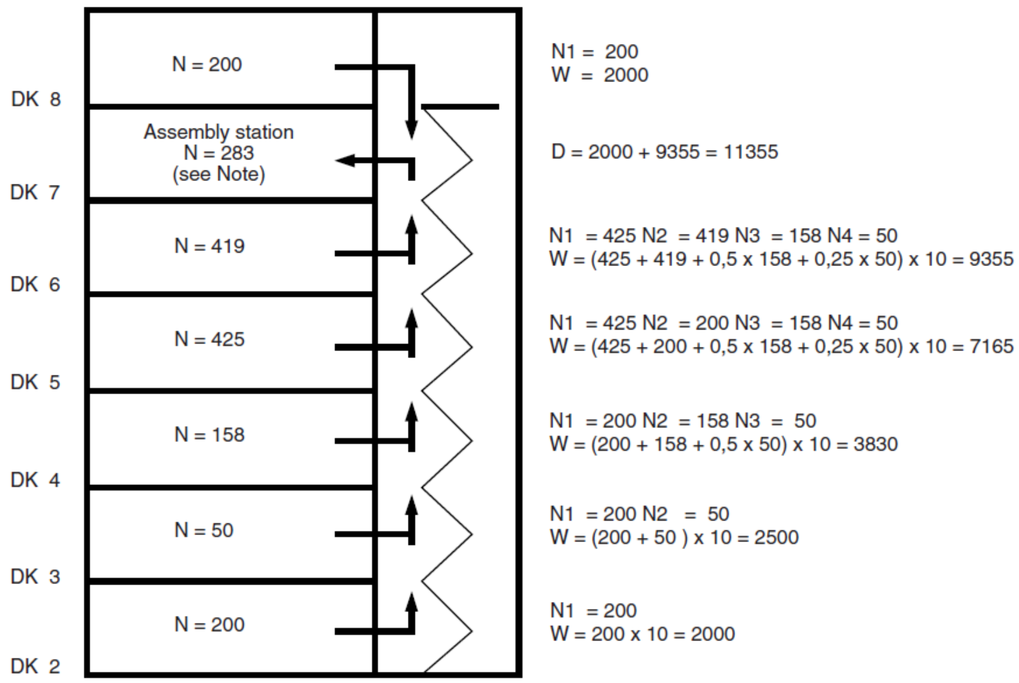
4) When the emergency fire pump is electrically driven, the power is to be supplied by a source other than that supplying the main fire pumps and to be located outside the engine room, and separated from it by an A class division, and the relevant electrical cables are not to pass through the compartment containing the main fire pump.

d) Testing of the emergency fire pump and its prime mover

1) Upon completion of the installation of the emergency fire pump, a running test is to be carried out to the satisfaction of the Society.

2) The emergency generator and its prime mover and any emergency accumulator battery are to be so arranged as to ensure that they will function at full rated power when the ship is upright and when inclined at any angle of list up to and including 22,5° either way or up to and including 10° inclination either way in the fore and aft direction. The above angles of list and trim are to be considered to occur simultaneously in their most unfavourable combination

Figure 11.1 : Minimum stairway width (W) calculation example



Z (pers) = number of persons expected to evacuate through the stairway

N (pers) = number of persons directly entering the stairway flow from a given deck

W (mm) = (N1 + N2 + 0.5 N3 + 0.25 N4) x 10 = calculated width of stairway

D (mm) = width of exit doors

N1 > N2 > N3 > N4 where:

N1 (pers) = the deck with the largest number of persons N entering directly the stairway

N2 (pers) = the deck with the next largest number of persons N entering directly the stairway, etc.

Note : The doors to the assembly station shall have aggregate widths of 11355 mm.

12 Arrangement of means of escape

12.1 Contents

12.1.1 The present Article 12 is based on the provisions of IMO Resolution A.757 (18) with the exception of item a) of 12.2.1, 12.2.2 and item a) of 12.2.3 which contain the requirements of Regulations II-2/28.1.51 to 28.1.5.5 of SOLAS Convention.

12.2 Passenger ships

12.2.1 Width of stairways

a) Basic requirements for stairway widths Stairways shall not be less than 900 mm in clear width.

The minimum clear width of stairways shall be increased by 10 mm for every one person provided for in excess of 90 persons. The total number of persons to be evacuated by such stairways shall be assumed to be two thirds of the crew and the total number of passengers in the areas served by such stairways. The width of the stairways shall not be inferior to those determined by item b) hereafter.

b) Calculation method of stairway widths

1) Basic principles of the calculation

- This calculation method determines the minimum stairway width at each deck level, taking into account the consecutive stairways leading into the stairway under consideration.
- It is the intention that the calculation method shall consider evacuation from enclosed spaces within each main vertical zone individually and take into account all of the persons using the stairway enclosures in each zone, even if they enter that stairway from another vertical zone.
- For each main vertical zone the calculation shall be completed for the night-time (case 1) and daytime (case 2) and the largest dimension from either case used for determining the stairway width for each deck under consideration.
- The calculation of stairway widths shall be based upon the crew and passenger load on each deck. Occupant loads shall be rated by the designer for passenger and crew accommodation spaces, service spaces, control spaces and machinery spaces. For the purpose of the calculation the maximum capacity of a public space

shall be defined by either of the following two values: the number of seats or similar arrangements, or the number obtained by assigning 2 m^2 of gross deck surface area to each person.

2) Calculation method for minimum value

- Basic formulae

In considering the design of stairway widths for each individual case which allow for the timely flow of persons evacuating to the assembly stations from adjacent decks above and below, the following calculation methods shall be used (see Figure 12.1 and Figure 11.1):

- when joining two decks:

W = (N1 + N2) x 10 mm

- when joining three decks:

W = (N1 + N2 + 0.5 N3) x 10 mm

- when joining four decks:

W = (N1 + N2 + 0.5 N3 + 0.25 N4) x 10 mm

- when joining five decks or more decks, the width of the stairways shall be determined by applying the above formula for four decks to the deck under consideration and to the consecutive deck, where:

W : The required tread width between handrails of the stairway.

The calculated value of W may be reduced where available landing area S is provided in stairways at the deck level defined by subtracting P from Z, such that:

$P = S \times 3{,}0$ persons/m^2; and $P_{max} = 0.25\ Z$

where:

Z : The total number of persons expected to be evacuated on the deck being considered

P : The number of persons taking temporary refuge on the stairway landing, which may be subtracted from Z to a maximum value of P = 0.25 Z (to be rounded down to the nearest whole number)

S : The surface area (m^2) of the landing, minus the surface area necessary for the opening of doors and minus the surface area necessary for accessing the flow on stairs (see Figure 12.2)

N : The total number of persons expected to use the stairway from each consecutive deck under consideration;

N1 is for the deck with the largest number of persons using that stairway; N2 is taken for the deck with the next highest number of persons directly entering the stairway flow such that when sizing the stairway width at each deck level:

N1 > N2 > N3 > N4 (see Figure 11.1).

These decks are assumed to be on or up-stream (i.e. away from the embarkation deck) of the deck being considered.

- Distribution of persons

The dimensions of the means of escape shall be calculated on the basis of the total number of persons expected to escape by the stairway and through doorways, corridors and landings (see Figure 12.2). Calculations shall be made separately for the two cases of occupancy of the spaces specified below. For each component part of the escape route, the dimension taken shall not be less than the largest dimension determined for each case:

Case 1:

- passengers in cabins with maximum berthing capacity fully occupied

- members of the crew in cabins occupied to 2/3 of maximum berthing capacity,

and

- service spaces occupied by 1/3 of the crew.

Case 2:

- passengers in public spaces occupied to ¾ of maximum capacity

- members of the crew in public spaces occupied to 1/3 of the maximum capacity

- service spaces occupied by 1/3 of the crew,

and

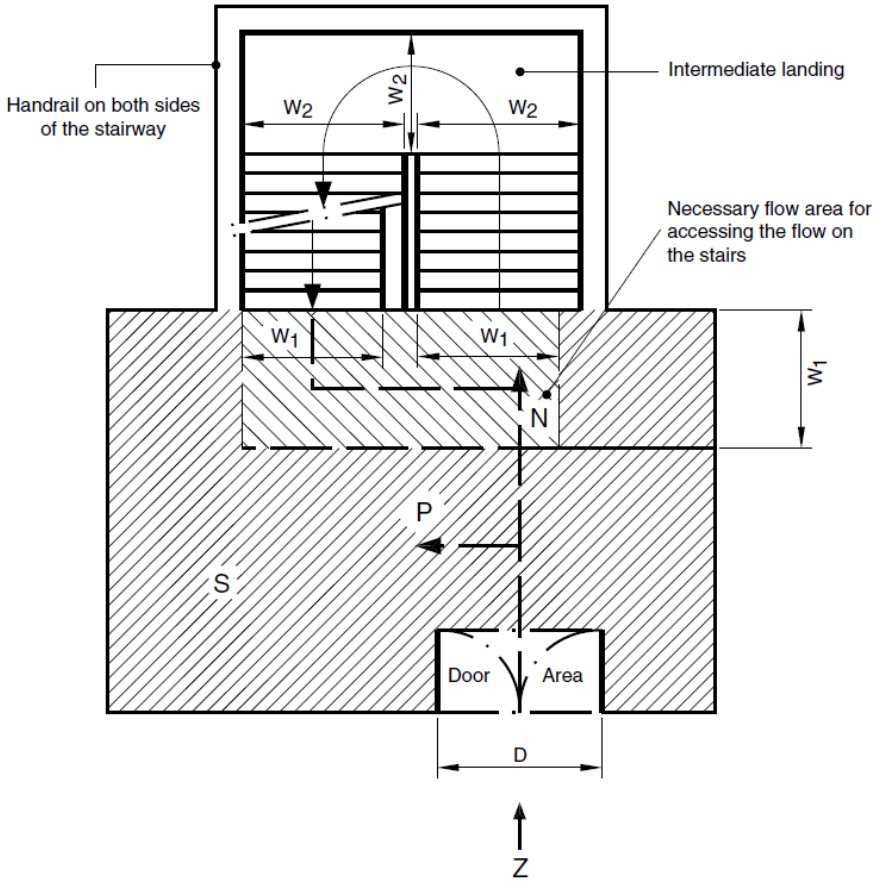
- crew accommodation occupied by 1/3 of the crew.

The maximum number of persons contained in a main vertical zone, including persons entering stairways from another main vertical zone, shall not be assumed to be higher than the maximum number of persons authorized to be carried on board for the calculation of stairway widths only.

c) Prohibition of decrease in width in the direction to the assembly station

The stairway shall not decrease in width in the direction of evacuation to the assembly station. Where several assembly stations are in one main vertical zone, the stairway width shall not decrease in the direction of the evacuation to the most distant assembly station.

Figure 12.1: Landing calculation for stairway width reduction



P = S x 3 persons/m2 = the number of persons taking refuge on the landing to a maximum of P = 0.25 Z

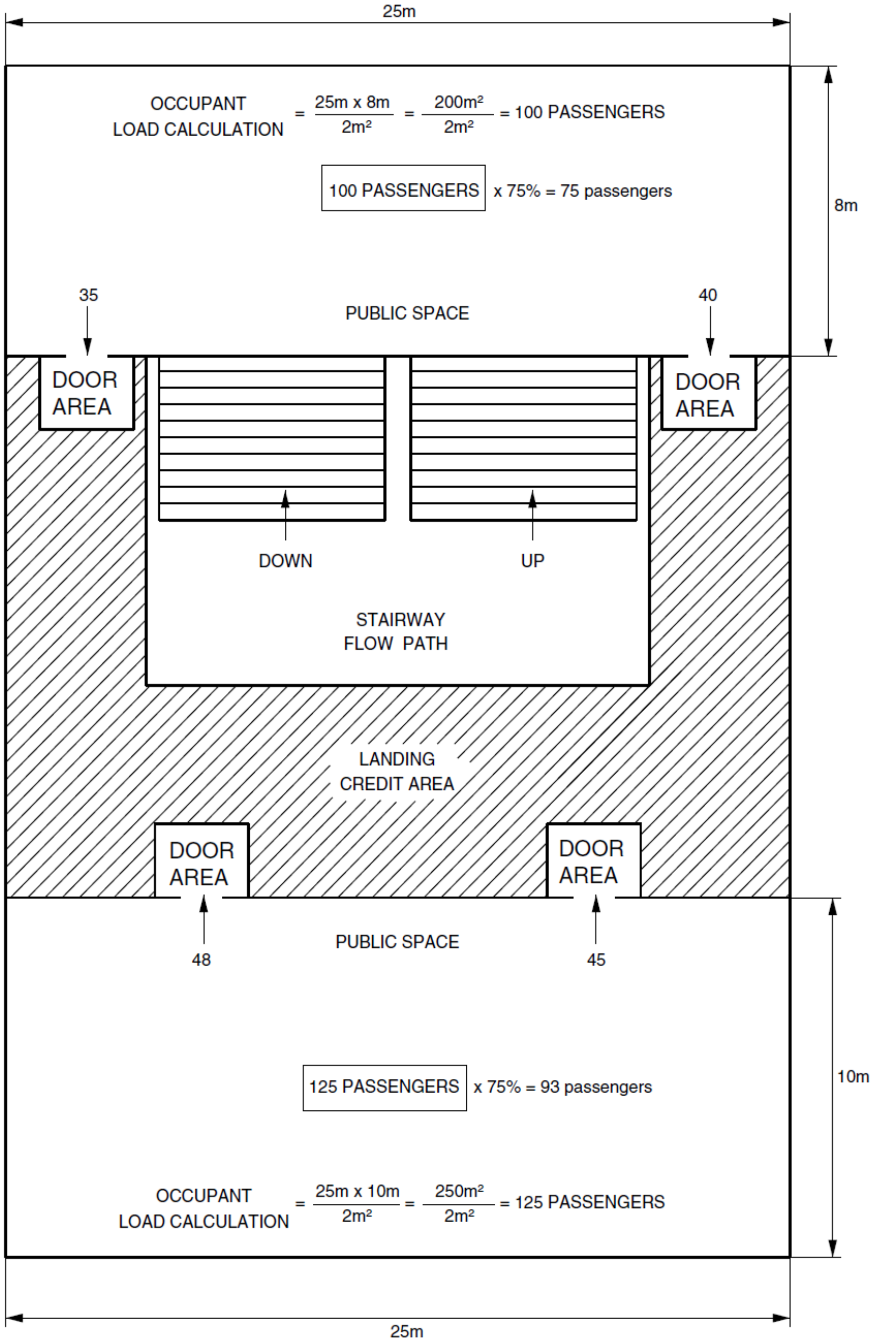
N = Z - P = the number of persons directly entering the stairway flow from a given deck

Z = number of persons to be evacuated from the deck considered

S = available landing area (m2) after subtracting the surface area necessary for movement and subtracting the space taken by the door swing area. Landing area is a sum of flow area, credit area and door area

D = width of exit doors to the stairway landing area (mm).

Figure 12.2: Occupant loading calculation example



12.2.2 Details of stairways

a) Handrails

Stairways shall be fitted with handrails on each side. The maximum clear width between handrails shall be 1800 mm.

b) Alignment of stairways

All stairways sized for more than 90 persons shall be aligned fore and aft.

c) Vertical rise and inclination

Stairways shall not exceed 3.5 m in vertical rise without the provision of a landing and shall not have an angle of inclination greater than 45°.

d) Landings

Landings at each deck level shall be not less than 2 m^2 in area and shall increase by 1 m^2 for every 10 persons provided for in excess of 20 persons, but need not exceed 16 m^2, except for those landings servicing public spaces having direct access onto the stairway enclosure.

12.2.3 Doorways and corridors

a) Doorways and corridors and intermediate landings included in means of escape shall be sized in the same manner as stairways.

b) The aggregate width of stairway exit doors to the assembly station shall not be less than the aggregate width of stairways serving this deck.

12.2.4 Evacuation routes to the embarkation deck

a) Assembly station

It shall be recognized that the evacuation routes to the embarkation deck may include an assembly station. In this case, consideration shall be given to the fire protection requirements and sizing of corridors and doors from the stairway enclosure to the assembly station and from the assembly station to the embarkation deck, noting that evacuation of persons from assembly stations to embarkation positions will be carried out in small controlled groups.

b) Routes from the assembly station to the survival craft embarkation position

Where the passengers and crew are held at an assembly station which is not at the survival craft embarkation position, the dimension of stairway width and doors from the assembly station to this position shall be based on the number of persons in the controlled group. The width of these stairways and doors need not exceed 1500 mm unless larger dimensions are required for evacuation of these spaces under normal conditions.

12.2.5 Means of escape plans

Means of escape plans shall be provided indicating the following:

a) the number of crew and passengers in all normally occupied spaces

b) the number of crew and passengers expected to escape by stairway and through doorways, corridors and landings

c) assembly stations and survival craft embarkation positions

d) primary and secondary means of escape, and

e) width of stairways, doors, corridors and landing areas.

Means of escape plans shall be accompanied by detailed calculations for determining the width of escape stairways, doors, corridors and landing areas (see also Sec 8, 2.6.4).

12.3 Cargo ships

12.3.1 Stairways and corridors used as means of escape shall be not less than 700 mm in clear width and shall have a handrail on one side. Stairways and corridors with a clear width of 1800 mm and over shall have handrails on both sides. Clear width is considered the distance between the handrail and the bulkhead on the other side or between the handrails. The angle of inclination of stairways should be, in general, 45°, but not greater than 50°, and in machinery spaces and small spaces not more than 60°. Doorways which give access to a stairway shall be of the same size as the stairway.