Rules for Classification and Construction

IV Industrial Services

6 Offshore Technology

5 Machinery Installations

Edition 2007
The following Rules come into force on November 1st, 2007

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Published by: Germanischer Lloyd Aktiengesellschaft, Hamburg
Printed by: Gebrüder Braasch GmbH, Hamburg
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Section 1

General Requirements and Instructions

A. Scope

1. These Rules are applicable to machinery and equipment essential to the safety and seaworthiness of mobile offshore units and fixed offshore installations, as defined in Chapter 1.

2. All machinery, electrical equipment, boilers and other pressure vessels, associated piping systems, fittings and wiring shall be of a design and construction adequate for the service for which they are intended and shall be so installed and protected as to reduce to a minimum any danger to the crew, due regard being paid to moving parts, hot surfaces and other hazards. The design shall have regard to materials used in construction, and to marine and industrial purposes for which the equipment is intended, the working conditions and the environmental conditions to which it will be subjected. Consideration shall be given to the consequence of the failure of the system and equipment essential to the safety of the installation/unit.

3. Machinery and equipment - for instance process and drilling machinery - which is not fully covered by these Rules, must comply with recognized codes and standards and may be required to undergo tests and trials.

4. Where machinery is used for propulsion of mobile units, it shall guarantee the unit’s adequate speed and manoeuvrability.

5. For machinery installations typical for use on ships and not covered by these Rules, such as propulsion and steering system (for the details compare Section 6, A.) reference is made to the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations.

6. In addition to the requirements contained in the Rules, GL reserve the right to impose further requirements in respect of all types of machinery where this is necessitated by new findings or operational experience. GL may permit deviations from the Rules so far the general safety standards are equivalently fulfilled.

7. National rules or regulations remain unaffected.

B. Documents for Approval

1. Before the start of manufacture, drawings showing the general layout of the machinery installation together with all drawings of parts subject to mandatory testing, to the extent specified in the following Sections of Chapter 5, are each to be submitted in triplicate to GL in German or English language.

GL reserve the right to require additional documentation if the submitted one is insufficient for an assessment of the unit/installation or essential parts thereof. This may especially be the case for plants and equipment related to new developments and/or which are not tested on board of installations/units to a sufficient extent.

Any non-standard symbols used are to be explained in a key list. All documents must show the number of the project and the name of the Owner/Operator and of the Builder.

2. The drawings shall contain all the data necessary for checking the design, the loads and the stresses imposed. Where necessary, design calculations relating to components and descriptions of the plant are also to be supplied.

3. The submitted calculations shall contain all necessary information concerning reference documents (parts of the specification, drawings, and global computations, computations for elements, following calculations). Literature used for the calculations has to be cited, important but not commonly known sources shall be added as copy.

The choice of computer programs according to the "State of the Art" is free. The programs may be checked by GL through comparative calculations with predefined test examples. A generally valid approval for a computer program is, however, not given by GL.

The calculations have to be compiled in a way which allows identifying and checking all steps of the calculations with regard to input and output in an easy way. Handwritten, easily readable documents are acceptable.

Comprehensive quantities of output data shall be presented in graphic form. A written comment to the main conclusions resulting from the calculations has to be provided.
4. Once the documents submitted have been approved by GL they are binding on the execution of the work. Any subsequent modifications require the approval by GL before being put into effect.

5. Manufacturers of machinery, boilers and auxiliary equipment shall supply a sufficient number of operating and maintenance notices and manuals together with the equipment. Instructions, warning signs, etc. have to be prepared in English and in the Operator's language.

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.

6. For further details see also Chapter 2 – Mobile Offshore Units, Section 1, C. and Chapter 3 – Fixed Offshore Installations, Section 1, C – Design Review.

C. Ambient Conditions

1. Ambient parameters

1.1 The selection, layout and arrangement of all machinery, equipment and appliances shall be such as to ensure faultless continuous operation under the ambient conditions specified in Tables 1.1 – 1.4 where applicable. Therefore the manufacturer/supplier shall be informed by the Owner/Operator about the expected environmental conditions.

1.2 Care has to be taken of the effects on the machinery installation caused by distortions of a unit’s hull.

1.3 For units/installations of unusual static and dynamic behaviour and intended for operation only in specified zones, GL may approve deviating ambient conditions.

Table 1.1 Temperatures and humidity

<table>
<thead>
<tr>
<th>Ambient temperature or suction air</th>
<th>Enclosed spaces</th>
<th>On open deck areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative humidity</td>
<td>Generally</td>
<td>100 %</td>
</tr>
<tr>
<td></td>
<td>In specially protected areas</td>
<td>80 %</td>
</tr>
<tr>
<td></td>
<td>For internal combustion engines</td>
<td>60 %</td>
</tr>
<tr>
<td>Seawater temperature</td>
<td>Generally</td>
<td>+32 °C</td>
</tr>
</tbody>
</table>

1 GL may approve lower temperatures for service in special geographical areas

Table 1.2 Inclinations of surface units

<table>
<thead>
<tr>
<th>Elements of machinery</th>
<th>Angle of inclination [°]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Athwartships</td>
</tr>
<tr>
<td></td>
<td>Static</td>
</tr>
<tr>
<td>Main engines and auxiliary machinery</td>
<td>15</td>
</tr>
<tr>
<td>Unit’s safety equipment including, for example, emergency source of power, emergency fire pumps and other drives</td>
<td>22,5  (^3)</td>
</tr>
<tr>
<td>Switchgear, electric and electronic equipment, remote control</td>
<td>22,5  (^3)</td>
</tr>
</tbody>
</table>

1 Up to an angle of inclination of 45 ° no undesired operations or functional changes may occur
2 Inclinations may occur simultaneously athwartships and longitudinally
3 On units carrying liquefied gases, the emergency power supply must also remain operational with the unit flooded up to a maximum final athwartship inclination of 30 °
4 Where the length of the unit exceeds 100 m, the fore-and-aft static angle of inclination may be taken as 500/L degrees
Table 1.3  Inclinations of column-stabilized units

<table>
<thead>
<tr>
<th>Elements of machinery</th>
<th>Angle of inclination in any direction [°] ¹</th>
<th>Static</th>
<th>Dynamic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main and auxiliary machinery essential to the propulsion and safety of the unit</td>
<td>15</td>
<td>22.5</td>
<td></td>
</tr>
<tr>
<td>Emergency machinery and equipment, fitted in accordance with statutory requirements</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

¹ Athwartships and fore and aft inclinations may occur simultaneously

Table 1.4  Inclinations of self-elevating units

<table>
<thead>
<tr>
<th>Elements of machinery</th>
<th>Angle of inclination in any direction [°] ¹</th>
<th>Static</th>
<th>Dynamic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery in elevated condition</td>
<td>10 ¹</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Machinery in floating condition</td>
<td>See Table 1.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Athwartships and fore and aft inclinations may occur simultaneously

2. Vibrations

2.1 General

2.1.1 Machinery, equipment and supporting structures are normally subjected to vibrations. 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 influences.

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 structural components from additional, excessive vibration effects liable to cause premature failures or malfunctions.

2.1.3 The following provisions relate to 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 an analogous manner.

2.1.4 Attention has to be paid to vibration stresses over the whole relevant operating range of the vibration source (exciter).

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

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 (cf. 2.2.1). This quantity is then compared with permissible or guaranteed values to check that it is admissible.

2.1.6 The procedure mentioned in 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 mechanical loads 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.
2.1.7 For reciprocating machinery, the following statements are only applicable for outputs over 100 kW and speeds below 3000 min⁻¹.

2.1.8 Regarding torsional vibrations see Section 7. Regarding dynamic loading of the structure see also Chapter 4, Section 3, H.

2.2 Assessment

2.2.1 In assessing the vibration stresses imposed on machinery, equipment and structures, the vibration velocity  \( \dot{v} \) 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 (cf. 2.1.2).

In the case of a purely sinusoidal oscillation, the effective value of the vibration velocity  \( v_{\text{eff}} \) can be calculated by the formula

\[
v_{\text{eff}} = \frac{1}{\sqrt{2}} \cdot \ddot{s} \cdot \omega = \frac{1}{\sqrt{2}} \cdot \dot{\hat{v}} = \frac{1}{\sqrt{2}} \cdot \ddot{a} \cdot \omega
\]  

(1)

\( \ddot{s} \) = vibration displacement amplitude

\( \dot{\hat{v}} \) = vibration velocity amplitude

\( v_{\text{eff}} \) = effective value of vibration velocity

\( \ddot{a} \) = vibration acceleration amplitude

\( \omega \) = 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:

\[
v_{\text{eff}} = \sqrt{v_{\text{eff}1}^2 + v_{\text{eff}2}^2 + \ldots + v_{\text{effn}}^2}
\]  

(2)

in which  \( v_{\text{effi}} \) is the effective value of the vibration velocity of the i-th harmonic component. Using formula (1), the individual values of  \( v_{\text{effi}} \) are to be calculated for each harmonic.

Depending on the prevailing conditions, the effective value of the vibration velocity is given by formula (1) for purely sinusoidal oscillations or by formula (2) for any periodic oscillation.

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 Fig. 1.1. The boundary curves of areas A, B and C are indicated in Table 1.5. If the vibration to be assessed comprises several harmonic components, the effective value according to 2.2.1 must be applied. The assessment of this value is to take account of all important harmonic components in the range from 2 to 300 Hz.

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

Otherwise, with GL’s consent, steps shall be taken (vibration damping, etc.) to reduce the actual vibration load to the proven permissible level for the equipment.

2.2.4 Reciprocating machines

2.2.4.1 Because they act as vibration exciters, reciprocating machines have to be separately considered. Both the vibrations 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) may, for the purpose of these Rules and with due regard to the limitations stated in 2.1.6, be assessed using the substitution quantities presented in 2.2.1.

2.2.4.2 In general the manufacturer of reciprocating machines is responsible and has to guarantee permissible vibration loads for the important directly connected peripheral equipment. The manufacturer of the reciprocating machine is responsible to GL for proving that the vibration loads are within the permissible limits, in accordance with 2.3.

2.2.4.3 Where the vibration loads of reciprocating machines lie within the area A’, separate consideration or proofs relating to the directly connected peripheral equipment (cf. 2.2.4.1) are not required. The same applies to machines and plant located in close proximity to the generator.

In such cases 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 2.2.4.2 lie below the boundary curve of area B, admissibility must be proved by measurement of the vibration load which actually occurs.

2.2.4.4 If the vibration loads of reciprocating machines lie outside area A’ but are still within area B’, it shall be proven by measurement that directly connected peripheral appliances are not subjected to loads exceeding area C.

In such cases 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 subject to higher loads than those defined by the limiting curve of area B.
Fig. 1.1 Areas for the assessment of vibration loads

Table 1.5 Numerical definition of the boundaries shown in Fig. 1.1.

<table>
<thead>
<tr>
<th>Areas</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>A'</th>
<th>B'</th>
</tr>
</thead>
<tbody>
<tr>
<td>(s) [mm]</td>
<td>&lt; 1,0</td>
<td>&lt; 1,0</td>
<td>&lt; 1</td>
<td>&lt; 1,0</td>
<td>&lt; 1,0</td>
</tr>
<tr>
<td>(\hat{v}) [mm]</td>
<td>&lt; 20,0</td>
<td>&lt; 35,0</td>
<td>&lt; 63,0</td>
<td>&lt; 20,0</td>
<td>&lt; 40,0</td>
</tr>
<tr>
<td>(v_{eff}) [mm]</td>
<td>&lt; 14,0</td>
<td>&lt; 25,0</td>
<td>&lt; 45,0</td>
<td>&lt; 14,0</td>
<td>&lt; 28,0</td>
</tr>
<tr>
<td>(\ddot{a}) [9,81m/s²]</td>
<td>&lt; 0,7</td>
<td>&lt; 1,6</td>
<td>&lt; 4</td>
<td>&lt; 1,3</td>
<td>&lt; 2,6</td>
</tr>
</tbody>
</table>

If the permissible vibration loads of individual directly connected peripheral appliances or machines in accordance with 2.2.4.2 lie below the stated values, admissibility must be proven by measurement of the vibration load which actually occurs.

2.2.4.5 If the vibration loads of reciprocating machines exceed 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 must in accordance with 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 2.2.4.4 (area B or a lower value specified by the manufacturer) continue to apply to these units.

2.2.4.6 For directly connected peripheral appliances, GL may approve higher values than those specified in 2.2.4.3, 2.2.4.4 and 2.2.4.5 where these are guaranteed by the manufacturer of the reciprocating machine in accordance with 2.2.4.2 and are proven in accordance with 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 2.3.
2.2.5 For appliances, equipment and components which, because of their installation in steering gear compartments or thruster compartments, are exposed to higher vibration stresses, the admissibility of the vibration load may, notwithstanding 2.2.3, be assessed according to the limits of area B. The design of such equipment shall be capable to withstand the above mentioned increased loads.

2.3 Proofs

2.3.1 Where in accordance with 2.2.4.2, 2.2.4.5 and 2.2.4.6 GL is asked to approve higher vibration load values, normally the binding guarantee of the admissible values by the manufacturer or the supplier is required. This confirmation may be based on adequate vibration tests, experience or other considerations.

2.3.2 GL reserve the right to call for detailed proof (calculations, design documents, measurements etc.) in cases where this is warranted.

2.3.3 Type approval in accordance with GL Rules VI- Additional Rules and Guidelines, Part 7 – Guidelines for the Performance of Type Approvals, Chapter 2 – Test Requirements for Electrical / Electronic Equipment and Systems is regarded as proof of admissibility of the tested vibration load.

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

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

2.4 Measurements

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 2.2.4.3 – 2.2.4.5 are met. Where circumstances warrant this, GL may also require proofs based on measurements for smaller outputs.

2.4.2 Measurements are to be performed in every case under realistic 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.

2.4.3 GL 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 proven.

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 may still be acknowledged if the essential conditions for this (similar bed construction, similar installation and pipe routing etc.) are satisfied.

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. Fig. 1.2 indicates the points of measurement which are normally required for an in-line piston engine. The measurement has to be performed in all three directions. In justified cases exceptions can be made regarding the inclusion of all the measuring points.

2.4.5 The measurements may 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 2.2.

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

D. Design and Construction of the Machinery Installations

1. Dimensioning

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

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

1.2 Where connections exist between systems or plant items which are designed for different forces, pressure 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.

![Diagram of in-line piston engine]

Fig. 1.2 Schematic representation of in-line piston engine

2. Materials

All components subject to these Rules shall comply with the GL Rules II – Materials and Welding.

3. Welding

The fabrication of welded components, the approval of manufacturing companies and the testing of welders are subject to the GL Rules II – Materials and Welding, Part 3 – Welding, Chapters 1 – 3.

4. Tests

4.1 Machinery and its component parts are subject to constructional and material tests, pressure and leakage tests, and trials. In the following Sections is prescribed which tests are to be carried out in presence of a GL Surveyor or which are even mandatory type-tests.

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

4.2 GL reserve 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.

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

4.4 After installation 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 a GL Surveyor.

In addition and where applicable, the propulsion installation is to be tested during sea trials, as far as possible under the intended service conditions.

5. Markings, identification

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

6. Fuels

6.1 The flash point of liquid fuels for the operation of boilers and diesel engines may not be lower than 60 °C.

For emergency generating sets, however, use may be made of fuels with a flash point \( \geq 43 \, ^\circ C \).

6.2 In exceptional cases, for units intended for operation in limited geographical areas or where special precautions subject to the approval of GL 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.

6.3 For the use of process gas see Section 11.

7. 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.

8. Control and regulating equipment

8.1 Machinery shall be so arranged and 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.
8.2 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 shall 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 condition)
- the power output or engine speed of the machinery being controlled or governed is not increased
- no unintentional start-up sequences are initiated

8.3 Where the main propulsion plant is manoeuvred with the aid of change-over gears or couplings, the control system is to be designed in such a way that the installation cannot be overloaded or damaged and the propulsion engine cannot be overloaded, stalled or run up to excessive speed due to operator error.

9. Availability of machinery

9.1 The machinery is to be so arranged and equipped that it can be brought into operation from the "dead condition" with the means available on board.

The "dead condition" means that the entire machinery 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 installation’s/unit’s electrical system, restarting auxiliary operation and bringing the propulsion installation of units back into operation.

To overcome the "dead 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. It is assumed that means are available to start the emergency generator at all times.

9.2 In case of "dead condition" it has to be ensured that it will be possible for the propulsion system of units and all necessary machinery of installations and units to be restarted within a period of 30 minutes, see Chapter 6 – Electrical Installations, Section 3, D.

10. Turning appliances

10.1 Machinery is to be equipped with the necessary turning appliances.

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

10.3 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.

E. Engine and Boiler Room Equipment

1. Operating and monitoring equipment

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.

1.2 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.

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

- protection against humidity and the accumulation of dirt
- compliance with the permissible working temperature range
- adequate ventilation
- adequate accessibility and illumination
- area classification

1.4 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.

2. Accessibility of machinery and boilers

2.1 All parts of machinery process and boiler installations shall be accessible for operation and maintenance.

2.2 Machinery and appliances are to be installed and arranged in such a way that assembly and inspection apertures are within reach and accessible at all times.

2.3 In the layout of machinery spaces (design of foundation structures, arrangement of piping and cable conduits, etc.) and the design of machinery and equipment (mountings for filters, coolers etc.), 2.2 is to be complied with.
2.4 Engine control rooms are to be provided with at least two exits, one of which can also be used as an escape route.

3. Lighting
All operating spaces have to be adequately lit to ensure that control of the plant or installation and reading of monitoring instruments is possible. In this connection see Chapter 6 – Electrical Installations, Section 10.

4. Bilges
All bilges shall be readily accessible, easy to clean and easily visible or adequately lit. Bilges beneath electrical machines are to be so designed as to prevent bilge water from penetrating into the machinery at angles of inclination specified in Tables 1.2 to 1.4 or due to motions of the unit.

5. Ventilation
Machinery, pump and operating rooms shall be capable of being adequately ventilated at all times, so that unrestricted operation of the machinery is ensured under any weather condition. This also applies when the weathertight covers stipulated in Rule 19 of the Load Line Convention of SOLAS are closed (Mobile units).

Ventilation is also to be provided for spaces in which combustible, toxic or asphyxiating gases or vapours may accumulate. (See also Section 2, C.)

6. Noise abatement
In compliance with the relevant national regulations, care is to be taken to ensure that operation of the installation/unit is not unacceptably impaired by engine noise.

F. 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 national regulations \(^1\) particular attention is to be paid to the following:

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.

2. When using hand cranks for starting internal combustion engine, 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.

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

4. In operating spaces, anti-skid floor plates and floor coverings shall be used.

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

7. Safety valves and shutoffs shall be capable of safe operation. Fixed steps, stairs or platforms shall be fitted where necessary.

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

9. Steam and feedwater lines, exhaust gas ducts, boilers and other equipment and piping systems carrying steam or hot fluids or gases are to be effectively insulated. Insulating materials shall be incombustible. Points at which combustible liquids or moisture can penetrate into the insulation shall be suitably protected, e.g. by means of shielding.

G. Communication and Signalling Equipment

1. Voice communication
Means of voice communication are to be provided between the unit’s manoeuvring station, the engine room and the steering gear compartment, and these means shall allow fully satisfactory intercommunication independent of the power supply on the unit under all operating conditions (see also Chapter 6 – Electrical Installations, Section 9).

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\(^1\) For units registered in the German Federation, the Accident-Prevention Regulations (Unfall-Vorschriften - UVV) of the See-Berufsgenossenschaft (See-BG) are applicable. For fixed installations located in German waters Regulations of the German Mining Authority, like BVOT, ELBergV, etc. have to be considered.
For offshore installations voice communication has to be established between the control centre and all engine rooms and other positions important for a safe operation.

2. Engineer alarm

From the engine room(s) or the engine control room it shall be possible to activate an alarm in the engineers’ living quarters (see also Chapter 6 – Electrical Installations, Section 12, G.1.).

3. Engine telegraph

For self-propelled mobile units the following has to be applied.

Machinery operated from the engine room shall 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.

For further details see Chapter 6 – Electrical Installations, Section 12, A.2.

4. Shaft revolution indicator

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

Barred speed ranges are to be marked on the shaft revolution indicators, see Section 7, D.

5. Design of communication and signalling 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 "Aster", of the reversing control of self-propelled mobile units is to be clearly indicated on the propulsion plant control platform.

Signalling devices shall 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 Chapter 6 – Electrical Installations, Section 12.

H. Essential Equipment

1. Principal requirements

Essential equipment is required to ensure continuity of the following functions:

- propulsion, manoeuvrability, navigation of mobile offshore units
- safety of mobile offshore units and fixed offshore installations
- safety of the crew
- functioning of all equipment, machinery and appliances needed for safe operation, like flooding control, fire fighting, ventilation, life saving appliances, etc.
- functioning of all equipment, machinery and appliances needed to an unrestricted extent for the primary duty of the offshore unit or installation

These requirements apply for the mechanical part of the equipment and complete equipment units supplied by subcontractors.

Essential equipment is subdivided into:

- primary essential equipment according to 2.
- secondary essential equipment according to 3.

2. Primary essential equipment

Primary essential equipment is that required to be operative at all times to maintain the manoeuvrability as regards propulsion and steering of a mobile unit or the safe stability of a fixed installation and that required directly for the primary duty of units or installations.

It comprises e.g.:

- steering gear of mobile units
- main propulsion plant with internal combustion engines and gas turbines, gears, main shafting, propellers of units
- controllable pitch propeller installation of units
- scavenging air blowers, fuel oil supply pumps, fuel booster pumps, fuel valve cooling pumps, lubricating oil pumps, cooling water pumps for main and auxiliary engines and turbines necessary for propulsion of units
- dynamic positioning system of floating and semi-submersible units, including various propulsion elements and related auxiliary systems, like lubricating oil pumps, cooling water pumps, etc.
- jacking system
- anchoring and mooring systems for exact position keeping as used for tension leg platforms, pipelaying units, FPSO, FSO, etc.
3. Secondary essential equipment

Secondary essential equipment is that required for the safety of unit/installation and crew, and is such equipment which can briefly be taken out of service without the propulsion, steering, position keeping and equipment needed for the primary duty of the unit or installation, being acceptably impaired.

It comprises e.g.:

- windlasses and capstans not directly used for exact position keeping
- dynamic positioning equipment, if it is auxiliary equipment
- fuel oil transfer pumps and fuel oil treatment equipment
- lubrication oil transfer pumps and lubrication oil treatment equipment
- starting air and control air compressors
- other starting installations for auxiliary and main engines
- turning device for main engines
- bilge, ballast and heel-compensating installations
- fire pumps and other fire fighting installations
- ventilating fans for engine and boiler rooms
- equipment considered necessary to maintain endangered spaces in a safe condition
- equipment for watertight closing appliances
- generator units supplying secondary essential equipment, if this equipment is not supplied by generators as described in 2.
- hydraulic pumps for secondary essential equipment
- parts of the installations for helicopter operation
- auxiliary equipment assisting the primary duty of the unit/installation

4. Non-essential equipment

Non-essential equipment is that, where temporary disconnection does not impair the principal requirements defined in 1.
Section 2

Area Classification and Ventilation

A. General

1. Scope

This Section applies to installations/units carrying facilities and equipment for drilling and for production of hydrocarbons which, due to their nature and properties, present high risks for human life and the installations. In order to avoid danger for installations and personnel, hazardous and non-hazardous areas have to be clearly defined, taking into account the structural arrangements as well as the substances to be handled, processed or stored.

2. Definitions

2.1 Hazardous areas

Hazardous areas in the understanding of these regulations are areas where "hazardous substances" may cause explosions, fires and ensuing catastrophes or may be the cause for injury, illness or death. Such substances may be explosive, flammable, toxic, acidizing, irritating or otherwise harmful to human life or installations.

Within such areas measures have to be taken ensuring that no source for gas escape and/or ignition will exist and sufficient means are easily and immediately available for the protection of human life and the installations.

For locations see 2.2.

2.2 Non-hazardous areas

Non-hazardous areas are understood to be locations where the existence of ignitable gas/air mixtures or escape gas can be excluded in normal operation.

The terms "hazardous area" and "non-hazardous area" apply to outdoor locations and enclosed or partially enclosed spaces.

2.3 Enclosed spaces

Enclosed spaces are closed rooms which may be provided only with the absolutely necessary openings, such as doors, windows, ventilation ducts, etc.

2.4 Partially-enclosed locations

Partially-enclosed locations are spaces which are not closed on all sides or not closed completely, but where natural ventilation is not ensured.

2.5 Outdoor locations

Outdoor locations are areas where natural ventilation is not impeded.

3. Documents for approval

Documents for review and approval shall be submitted for examination in triplicate, showing the general arrangement, the intended purpose of each room and the ventilation system with respect to the area classification. All relevant information about fire rating of bulkheads and decks, fire doors, fire dampers, ventilation ducts and data of the ventilation system is to be provided.

The particulars of the ventilation system such as fan control position, position of flaps or fire dampers and their identification numbers are to be entered into the fire control and safety plan.

B. Classification of Areas

1. Principles

1.1 For the purpose of selection and installation of machinery and electrical equipment hazardous areas are divided into Zones as follows:

Zone 0: in which an ignitable gas/air mixture is continuously present, or present for long periods;

Zone 1: in which an ignitable gas/air mixture is likely to occur;

Zone 2: in which an ignitable gas/air mixture is not likely to occur, and if it occurs, it will only exist for a short time.

This area classification is valid only for normal operating conditions.

1.2 The following aspects for the determination of hazardous and non-hazardous areas have to be additionally considered:

− physical properties of the ignitable substances
− quantity, pressure and temperature of substance released
− environmental conditions
− method of ventilation
1.3 As the boundaries of areas cannot be definitely stated to cover all possible situations, each individual case has to be considered under the aspect of sound engineering practice. The boundaries of the different Zones may be determined in accordance with relevant recognized standards or codes of practice, e.g. IEC 60079-10, IP (Institute of Petroleum, GB) Code No. 15, API (American Petroleum Institute) RP 505.

1.4 Personnel safety with respect to toxic substances (e.g. H2S) is to be considered separately.

2. Details of classification

2.1 Hazardous areas Zone 0

Hazardous areas Zone 0 include, but are not limited to:

2.1.1 The internal spaces of closed tanks and pipes for active drilling mud, as well as oil and gas products and treating facilities, e.g. escape gas outlet pipes, or spaces in which an oil/gas/air mixture is continuously present, or present for long periods.

2.1.2 A spherical space surrounding an escape or vent gas outlet has to be defined as a Zone 0 area, if gas is released continuously or for extended periods. For the determination of the radius of the spherical space the pressure, properties and quantity of the released substances as well as environmental factors have to be taken into consideration.

2.2 Hazardous areas Zone 1

Hazardous areas Zone 1 include, but are not limited to:

2.2.1 Enclosed and partially enclosed locations which are below the drill floor and contain a possible source of release, such as the top of the bell nipple.

2.2.2 Enclosed spaces which are located on the drill floor and which are not separated by a solid floor from the spaces mentioned in 2.2.1.

2.2.3 In outdoor or partially enclosed locations, except as provided for in 2.2.1, the area within 1.5 metres from the boundaries of any openings to equipment which is part of the mud system, any ventilation outlets of Zone 1 spaces, or any access to Zone 1 spaces.

2.2.4 Enclosed spaces containing any part of the mud circulation system which has an opening into these spaces and is located between the well and the final degassing discharge.

2.2.5 Pits, ducts or similar structures in locations which otherwise would be Zone 2 but which are so arranged that dispersion of gas may not occur.

2.2.6 Enclosed and partially enclosed wellhead decks as well as partially enclosed decks below or above, which are not separated leak proof and where natural ventilation is impeded.

2.2.7 Enclosed spaces for oil and gas treating facilities which are not adequately ventilated.

2.3 Hazardous areas Zone 2

Hazardous areas Zone 2 include but are not limited to:

2.3.1 Partially enclosed derricks to the extent of their enclosure above the drill floor or to a height of 3 metres above the drill floor, whichever is greater.

2.3.2 Outdoor locations within the boundaries of the drilling derrick up to a height of 3 metres above the drill floor and immediately adjacent to it, i.e. draw works, compounds, gears.

2.3.3 Partially enclosed locations below and adjacent to the drill floor up to the boundaries of the derrick, or extent of any enclosure which may trap gases.

2.3.4 Outdoor locations below the drill floor and within a radius of 3 metres from points which may be the cause of gas release as, e.g., the bell nipple and its piping.

2.3.5 Enclosed spaces which contain open sections of the mud circulation system from the final degassing discharge up to the pump suction connection at the mud pit.

2.3.6 Partially enclosed spaces for oil and gas treating facilities where natural ventilation is impeded.

2.3.7 The areas 1.5 metres beyond Zone 1 areas as specified in 2.2.3, as well as beyond partially enclosed locations specified in 2.2.1.

2.3.8 Outdoor areas within 1.5 metres of the boundaries of any ventilation outlet from or access to a Zone 2 space.

2.3.9 Air locks between a Zone 1 and a non-hazardous space.

3. Openings, access and ventilation conditions affecting the extent of hazardous areas

3.1 Except for operational reasons access doors or other openings shall neither be provided between a non-hazardous space and a hazardous area, nor between a Zone 2 and a Zone 1 space.

Where such access doors or other openings are provided, any enclosed space not referred to under 2.2 or 2.3, yet having a direct access to any Zone 1 or Zone 2 location, becomes the same Zone as that location, with the following exceptions.
3.2 An enclosed space with direct access to any Zone 1 location can be considered as Zone 2 if – the access is fitted with a gas-tight door opening into the Zone 2 space, and

- ventilation is such that the air flow with the door open is directed from the Zone 2 space into the Zone 1 location, and
- loss of ventilation is alarmed at a manned station.

3.3 An enclosed space with direct access to any Zone 2 location is considered non-hazardous if

- the access is fitted with a self-closing gastight door that opens into the non-hazardous location, and
- ventilation is such that the air flow with the doors open is directed from the non-hazardous space into the Zone 2 location, and
- loss of ventilation is alarmed at a manned station (for minimum overpressure see C.4.)

3.4 An enclosed space with direct access to any Zone 1 location is considered non-hazardous if

- the access is fitted with gas-tight self-closing doors forming an air lock, and
- the space has ventilation overpressure in relation to the hazardous space and
- loss of ventilation overpressure is alarmed at a manned station (for minimum overpressure see C.4.)

Where in special cases ventilation arrangements of the intended safe space are considered sufficient by GL to prevent any ingress of gas from the Zone 1 location, the two self-closing doors forming an air lock may be replaced by a single self-closing gastight door which opens into the non-hazardous location and has no hold-back device.

3.5 For pressurized rooms on fixed offshore installations reference is made to IEC 60 079-13.

3.6 Piping systems shall be designed to preclude direct connection between hazardous areas of different classification and between hazardous and non-hazardous areas.

C. Ventilation

1. General

1.1 Attention shall be given to ventilation inlet and outlet locations and air flow in order to minimize the possibility of cross contamination. Inlets are to be located in non-hazardous areas as high and as far away from any hazardous area as practicable.

1.2 The arrangement of ventilation inlet and outlet openings in an enclosed space shall be such that the entire room is effectively ventilated, giving special consideration to air consumption by and location of the equipment.

1.3 Each air outlet shall be located in an outdoor area which, in the absence of the considered outlet, is of the same or lesser hazard than the ventilated space.

1.4 Ventilation for hazardous areas is to be completely separate from that used for non-hazardous areas. Adequate discharge of exhaust air under all environmental conditions shall be considered.

1.5 Where natural ventilation is applied, the effectiveness of the system has to be proved.

1.6 Additionally the following aspects shall be considered:

- the maintaining of suitable temperatures, supplies of fresh air, humidity conditions and acceptable levels of noise
- thermal insulation
- air filtration
- provision of standby equipment

2. Ventilation of hazardous areas

Enclosed hazardous areas shall be provided with adequate ventilation establishing a lower pressure in relation to the overpressure in the adjacent less hazardous spaces or zones. Special consideration shall be given to location of equipment which may release gas, and to spaces where gas may accumulate. Where the inlet duct passes through a more hazardous area, it has to have overpressure in relation to this area.

The outlet air from Zone 1 and Zone 2 spaces shall be led in separate ducts to outdoor locations. The internal spaces of such ducts belong to the same zone as the ventilated space.

3. Ventilation of non-hazardous areas

Enclosed living and working areas are to be maintained under overpressure in relation to adjacent hazardous locations. Where the inlet duct passes through a hazardous area, it has to have overpressure in relation to the hazardous area. Exceptions may be allowed, if the ducts in the hazardous area are made gastight and have particularly thick walls. For control stations alternative and separate means of air supply shall be provided; air inlets of the two sources of supply shall be so disposed that the risk of both inlets drawing in smoke or flammable mixtures simultaneously is minimized.
4. Values of air flow and overpressure

4.1 At least 20 air changes per hour have to be achieved in spaces of Zone 1, and at least 12 in spaces of Zone 2. During start-up or after shut-down it is necessary either to ensure that the internal atmosphere is not hazardous, or to proceed with prior purging of sufficient duration. Generally, the volume for purging is estimated as at least five times the internal volume of the room and its associated ducts.

4.2 Where forced ventilation is provided for overpressure, a minimum of 25 Pa (0.25 mbar) with respect to the outer atmosphere shall be maintained at all points inside the space. If there is any air-consuming equipment inside the pressurised room, the ventilation flow shall be capable of covering all needs.

5. Ducts and shutters

5.1 Air ducts have to be made of steel or other equivalent material, where "equivalent material" means any material which, by itself, or due to insulation provided, has structural properties equivalent to steel at the end of the applicable fire exposure to the standard fire test (e.g. aluminium with appropriate insulation). The ducts have to be protected against corrosion and shall be provided with means for inspection.

5.2 Ducts provided for ventilation of accommodations, service spaces or control stations shall not in general pass through working spaces.

Ducts provided for ventilation of working areas shall not pass through accommodations, service spaces or control stations.

5.3 The exhaust ducts from galley ranges shall be constructed of "A" Class divisions, compare Section 10, A.3. 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) an off-switch (actuated from the galley) for the fan, if power ventilation is provided;
   d) fixed means for extinguishing a fire within the duct.

5.4 The main inlets and outlets of all ventilation systems shall be capable of being closed from outside the area being ventilated. Ducts with a sectional area exceeding 750 cm² and penetrating class A or B bulkheads and decks are additionally to have fire dampers with melting fuse or plug or other equivalent arrangement. The fire dampers shall close automatically at a temperature above 70 °C. In the closed condition fire dampers shall rest firmly and throughout on sealing steel bars and be capable of being arrested. Their position shall be clearly and permanently indicated. Reference is made to Section 10.

6. For further details see also Section 10, B.5 and GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 21 – Ventilation.

D. Machinery and Electrical Installations in Hazardous Areas

1. Machinery installations

1.1 Mechanical equipment shall be limited to that necessary for operational purposes.

1.2 Mechanical equipment and machinery in hazardous areas shall be so constructed and installed as to prevent the risk of ignition from sparking due to the formation of static electricity or friction between moving parts, and from high temperatures of exposed parts due to exhausts or other emissions.

1.3 No surfaces shall reach unacceptable high temperatures.

1.4 The installation of internal combustion machinery may be permitted in Zone 1 and Zone 2 hazardous areas, provided that GL is satisfied that sufficient precautions have been taken against the risk of ignition.

1.5 The installation of fired equipment may be permitted in Zone 2 hazardous areas, provided that GL is satisfied that sufficient precaution has been taken against the risk of ignition.

1.6 Fans are to be provided with protective devices preventing ingress of solid matter; these protective devices must be conductively connected to the installation for proper earthing. Fans have to be of non-sparking design, see Chapter 6 – Electrical Installations, Section 15, J.3.

2. Electrical installations

Electrical equipment and wiring installed in hazardous areas shall be limited to that necessary for operation purposes and shall comply with the requirements stipulated in Chapter 6 – Electrical Installations, Section 13.

3. National regulations

National regulations of the flag state and/or the state of the operation location have to be considered. This applies especially for fixed offshore installations.

4. Occurring gas

The type of the occurring gas or gases has to be considered establishing protective measures.
E. Alarm, Control and Monitoring Systems

1. Alarms

For enclosed spaces of hazardous and non-hazardous areas, as well as for gas-tight enclosures, visual and audible alarms have to be provided, which in the event of insufficient air pressure will be indicated locally and in the control room and/or safety station. Provision has to be made that the ventilator system can be stopped from the control room/safety station or outside control panels.

2. Gas detection

Gas detectors have to be provided at air outlets of hazardous areas and air inlets of non-hazardous areas. The gas detection and alarm systems shall fulfil the requirements outlined in Chapter 6, Section 9, D.

3. Fire extinguishing

Where CO₂ fire extinguishing systems are used, means have to be provided for automatically stopping all ventilation fans serving the protected space before the medium is released.

4. Ventilation

Ventilation of the accommodation area shall be arranged for
- automatic stop of fans and
- automatic closure of fire dampers,
- if a fire or gas alarm is activated.

5. Testing

Suitable provision shall be made to enable the equipment to be readily tested without disrupting the normal routine of the installation.
Section 3

Internal Combustion Engines and Air Compressors

A. General

1. Scope

The Rules contained in this Section are valid for internal combustion engines as main and auxiliary drives as well as air compressors. Internal combustion engines in the sense of these Rules are non-reversible, four-stroke diesel engines with trunk piston.

For the purpose of these requirements, internal combustion engines are diesel engines.

For other types of internal combustion engines the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 2 are to be applied.

2. Ambient conditions

For all engines, which are used on units/installations, the definition of the performance has to be based on the ambient conditions according to Section 1, C.

3. Rated power

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 Section 1, C. can be delivered as continuous power. Diesel engines are to be capable of continuous operation within power range 1 in Fig. 3.1 and of short period operation in power range 2. The extent of the power ranges is to be stated by the engine manufacturer.

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.

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 GL.

3.4 After running on the test bed, the fuel delivery system of main engines is normally to be so adjusted that overload power cannot be given in service. The limitation of the fuel delivery system has to be secured permanently.

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

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

3.7 For main engines, a power diagram (Fig. 3.1) is to be prepared showing the power ranges within which the engine is able to operate continuously and for short periods under service conditions.

4. Fuels

4.1 The use of liquid fuels is subject to the Rules contained in Section 1, D.6.

4.2 For fuel treatment and supply, see Section 13e, D.

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.
6. Electronic components and systems

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

6.2 Electronic components and systems have to be type approved according to GL Rules VI – Additional Rules and Guidelines, Part 7 – Guidelines for the Performance of Type Approvals, Chapter 2 – Test Requirements for Electrical/Electronic Equipment and Systems.

6.3 For computer systems the Rules according to Chapter 6 – Electrical Installations, Section 9, D. have to be observed.

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

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

6.6 Where the electronic control system incorporates a speed control, F.1.3 and Chapter 6 – Electrical Installations, Section 9, C.11. have to be observed.

7. Local control station

7.1 For the local control station, I. has to be observed.

7.2 The indicators named in I. shall be realised 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.

7.3 Where these indicators are realised electrically, the power supply of the instruments and of the electronic system has to be realised in such way to ensure the behaviour stated in 7.2.

B. Documents for Approval

1. General

The general conditions for these documents are defined in Section 1, B. For each engine type the drawings and documents listed in Table 3.1 shall, wherever applicable, be submitted by the engine manufacturer to GL for approval (A) or information (R). Where considered necessary, GL may request further documents to be submitted. This also applies to the documentation of design changes according to 4.

2. Engines manufactured under licence

For each engine type manufactured under licence, the licensee shall submit to GL, as a minimum requirement, the following documents:

- comparison of all the drawings and documents as per Table 3.1 - where applicable – indicating the relevant drawings used by the licensee and the licensor
- all drawings of modified components, if available, as per Table 3.1 together with the licensor's declaration of consent to the modifications
- a complete set of drawings at the disposal of the local inspection office of Germanischer Lloyd as a basis for the tests and inspections

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
- fuels which can be used
- working cycle (4-stroke)
- method of gas exchange (naturally aspirated or supercharged)
- rated power per cylinder at rated speed and maximum continuous brake mean effective pressure
- method of pressure charging (pulsating pressure system or constant-pressure system)
- charge air cooling system
- cylinder arrangement (in-line, vee)

4. Design modifications

Following initial approval of an engine type by GL, only those documents listed in Table 3.1 require to be resubmitted for examination which embody important design modifications.

5. Additional engine components

For the approval of exhaust gas turbochargers, heat exchangers, engine-driven pumps, etc. the corresponding applications are to be submitted to GL by the respective manufacturer.
Table 3.1 Documents for approval

<table>
<thead>
<tr>
<th>Serial no.</th>
<th>A / R</th>
<th>Description</th>
<th>Quantity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R</td>
<td>Details required on GL Forms F144 and F144/1 when applying for approval of an internal combustion engine</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>R</td>
<td>Engine transverse cross-section</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>R</td>
<td>Engine longitudinal section</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>R</td>
<td>Cast bedplate and crankcase</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>R</td>
<td>Thrust bearing assembly</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>R</td>
<td>Cast thrust bearing bedplate</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>R</td>
<td>Tie rod</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>R</td>
<td>Cylinder cover/head, assembly</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>R</td>
<td>Cylinder liner</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>A</td>
<td>Crankshaft, details for each number of cylinder, with data sheets for calculation of crankshaft</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>A</td>
<td>Crankshaft, assembly for each number of cylinders</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>A</td>
<td>Shaft coupling bolts</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>R</td>
<td>Counterweight (it not integral with crankshaft), including fastening</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>R</td>
<td>Connecting rod, details</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>R</td>
<td>Connecting rod, assembly</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>R</td>
<td>Piston assembly</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>R</td>
<td>Camshaft drive, assembly</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>A</td>
<td>Material specification of main parts with information on non-destructive tests and pressure tests</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>19</td>
<td>A</td>
<td>Arrangement of foundation (for main engines only)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>A</td>
<td>Schematic layout or other equivalent documents of starting air system</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>21</td>
<td>A</td>
<td>Schematic layout or other equivalent documents of fuel oil system</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>22</td>
<td>A</td>
<td>Schematic layout or other equivalent documents of lubricating oil system</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>23</td>
<td>A</td>
<td>Schematic layout or other equivalent documents of cooling water system</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>24</td>
<td>A</td>
<td>Schematic diagram of engine control and safety system</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>25</td>
<td>A</td>
<td>Schematic diagram of electronic components and systems</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>R</td>
<td>Shielding and insulation of exhaust pipes, assembly</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>A</td>
<td>Shielding of high pressure fuel pipes, assembly</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>A</td>
<td>Arrangement of crankcase explosion relief valves</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>29</td>
<td>R</td>
<td>Operation and service manuals</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>30</td>
<td>A</td>
<td>Schematic layout or other equivalent documents of hydraulic system (for valve lift) on the engine</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>A</td>
<td>Type test program and type test report</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>A</td>
<td>High pressure parts for fuel oil injection system</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

**A** for approval

**R** for reference

1. if integral with engine and not integrated in the bedplate
2. all engines
3. only for engines with a bore > 200 mm or a crankcase volume $\geq 0.6 \text{ m}^3$
4. and the system so far as supplied by the engine manufacturer. If engines incorporate electric control systems a failure mode and effects analysis (FMEA) 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 engine will not be lost or degraded beyond an acceptable performance criteria of the engine
5. 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 fittings/settings together with any test requirements on completion of maintenance
6. for comparison with GL requirements for material, NDT and pressure testing as applicable
7. the documentation has to contain specification of pressures, pipe dimensions and material
C. Crankshaft Calculation

1. Design methods

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 GL Rules VI – Additional Rules and Guidelines, Part 4 – Diesel Engines, Chapter 2 – Guidelines for the Calculation of Crankshafts for I.C. Engines. Other methods of calculation may be used provided that they do not result in crankshaft dimensions smaller than those obtained by applying the aforementioned regulations.

1.2 Outside the end bearings, crankshafts designed according to the requirements specified in 1.1 may be adapted to the diameter of the adjoining shaft d by a generous fillet \( r \geq 0.06 \cdot d \) or a taper.

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 GL.

2. Screw joints

2.1 Split crank shafts

Only fitted bolts may be used for assembling split crankshafts.

2.2 Power-end flange couplings

The bolts used to connect power-end flange couplings are normally to be designed as fitted bolts in accordance with Section 5, G.3.

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

3. Torsional vibration, critical speeds

Section 7 applies.

D. Materials

1. Approved materials

1.1 The mechanical characteristics of materials used for the components of diesel engines have to conform to GL Rules II – Materials and Welding, Part 1 – Metallic Materials, Chapter 2 – Steel and Iron Materials. The materials approved for the various components are shown in Table 3.3 together with their minimum required characteristics and material Certificates.

1.2 Materials with properties deviating from those specified may be used only with GL’s special approval. GL requires proof of the suitability of such materials.

2. Testing of materials

2.1 In the case of individually produced engines, the following parts are to be subjected to material tests in the presence of GL’s representative.

1. Crankshaft
2. Crankshaft coupling flange (non-integral) for main power transmission
3. Crankshaft coupling bolts
4. Pistons or piston crowns made of steel, cast steel or nodular cast iron
5. Connecting rods including the associated bearing covers
6. Cylinder liners made of steel or cast steel
7. Cylinder covers made of steel or cast steel
8. Tie rods
9. Bolts and studs for:
   – cylinder covers
   – main bearings
   – connecting rod bearings
10. Camshaft drive gear wheels and chain wheels made of steel or cast steel.

Table 3.2 Material tests

<table>
<thead>
<tr>
<th>Cylinder bore</th>
<th>Parts to be tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 300 \text{ mm} )</td>
<td>1 – 5 – 8</td>
</tr>
<tr>
<td>( &gt; 300 \leq 400 \text{ mm} )</td>
<td>1 – 5 – 6 – 7 – 8 – 9</td>
</tr>
<tr>
<td>( &gt; 400 \text{ mm} )</td>
<td>all parts</td>
</tr>
</tbody>
</table>
2.1.1 Material tests are to be performed in accordance with Table 3.2.

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, see Section 13d, C.

2.1.3 Material for charge air coolers are to be supplied with Manufacturer Test Reports.

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 3.4 and 3.5:

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. Connecting rods
5. Piston crowns of steel or cast steel
6. Tie rods (at each thread over a distance corresponding to twice the threaded length)
7. Bolts which are subjected to alternating loads, e.g.:
   - main bearing bolts
   - connecting rod bolts
   - cylinder cover bolts
8. Cylinder covers made of steel or cast steel
9. Camshaft drive gear wheels made of steel or cast steel

2.2.1 Magnetic particle or dye penetrant tests are to be performed in accordance with Table 3.4 at those points, to be agreed between the GL Surveyor and the manufacturer, where experience shows that defects are liable to occur.

2.2.2 Ultrasonic tests are to be carried out by the manufacturer in accordance with Table 3.5, and the corresponding signed manufacturer’s Certificates are to be submitted.

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

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

2.3 Crankshafts welded together from forged or cast parts are subject to GL special approval. Both the manufacturers and the welding process must have been accepted. The materials and the welds are to be tested.

E. Tests and Trials

1. Manufacturing inspections

1.1 The manufacture of all engines with GL Classification is subject to supervision by GL.

1.2 Where engine manufacturers have been approved by GL as “Suppliers of Mass Produced Engines”, these engines are to be tested in accordance with GL Guidelines VI – Additional Rules and Guidelines, Part 4 – Diesel Engines, Chapter 1 – Guidelines for Mass Produced Engines.

2. Pressure tests

The individual components of internal combustion engines are subject to pressure tests at the pressures specified in Table 3.6. GL Certificates are to be issued for the results of the pressure tests.

3. Type approval testing (TAT)

3.1 General

Engines for installation on board of the installation/unit have to be type tested by GL. For this purpose a type approval test in accordance with 3.1.2 is to be performed.

3.1.1 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 GL has been informed of the results of the major inspections
- GL has issued the necessary approval of drawings on the basis of the documents to be submitted in accordance with B.

3.1.2 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 GL during the type test.
- Stage B - Type test
  This test is to be performed in the presence of the GL Surveyor.
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 presented for inspection after type testing in accordance with 3.4, are to be stated.

### Table 3.3  Approved materials and type of test Certificate

<table>
<thead>
<tr>
<th>Approved materials</th>
<th>GL Rules *</th>
<th>Components</th>
<th>Test Certificate **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forged steel:</td>
<td>Section 3, C.</td>
<td>Crankshaft</td>
<td>A B C</td>
</tr>
<tr>
<td>Rm ≥ 360 N/mm²</td>
<td></td>
<td>Connection rods</td>
<td>X – –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Piston and piston crowns</td>
<td>X ³ X ⁴ –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylinder covers/heads</td>
<td>X – –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Camshaft drive wheels</td>
<td>X ³ X ⁴ –</td>
</tr>
<tr>
<td>Rolled and forged steel rounds:</td>
<td>Section 3, C.</td>
<td>Tie rods</td>
<td>X – –</td>
</tr>
<tr>
<td>Rm ≥ 360 N/mm²</td>
<td></td>
<td>Bolts and studs</td>
<td>X ¹ X ² –</td>
</tr>
<tr>
<td>Cast steel</td>
<td>Section 4, C.</td>
<td>Bearing transverse girders (weldable)</td>
<td>X – –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pistons and piston crowns</td>
<td>X ³ X ⁴ –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylinder covers/heads</td>
<td>X ¹ X ² –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Camshaft drive wheels</td>
<td>X ³ X ⁴ –</td>
</tr>
<tr>
<td>Nodular cast iron, preferably ferritic grades:</td>
<td>Section 5, B.</td>
<td>Engine blocks</td>
<td>– X ¹ –</td>
</tr>
<tr>
<td>Rm ≥ 370 N/mm²</td>
<td></td>
<td>Bedplates</td>
<td>– X ¹ –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylinder blocks</td>
<td>– X ¹ –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Piston and piston crowns</td>
<td>X ³ X ⁴ –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylinder covers/heads</td>
<td>– X ¹ –</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flywheels</td>
<td>– X ¹ –</td>
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<tr>
<td></td>
<td></td>
<td>Valve bodies</td>
<td>– X ¹ –</td>
</tr>
<tr>
<td>Lammelar cast iron:</td>
<td>Section 5, C.</td>
<td>Engine blocks</td>
<td>– – X</td>
</tr>
<tr>
<td>Rm ≥ 200 N/mm²</td>
<td></td>
<td>Bedplates</td>
<td>– – X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylinder blocks</td>
<td>– – X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylinder liners</td>
<td>– – X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylinder covers/heads</td>
<td>– – X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flywheels</td>
<td>– – X</td>
</tr>
</tbody>
</table>

* all details refer to GL Rules II – Materials and Welding, Part 1 – Metallic Materials, Chapter 2

** Test Certificates are to be issued in accordance with GL Rules II – Materials and Welding, Part 1 – Metallic Materials, Chapter 1 – Principles and Test Procedures – Section 1, H. with the following abbreviations:

- A: GL 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 3.4  Magnetic particle tests

<table>
<thead>
<tr>
<th>Cylinder bore</th>
<th>Parts to be tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 400 mm</td>
<td>1 – 2 – 3 – 4</td>
</tr>
<tr>
<td>&gt; 400 mm</td>
<td>all parts</td>
</tr>
</tbody>
</table>
Table 3.5 Ultrasonic tests

<table>
<thead>
<tr>
<th>Cylinder bore</th>
<th>Parts to be tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 400 mm</td>
<td>1 – 2 – 3 – 4 – 5 – 8</td>
</tr>
<tr>
<td>&gt; 400 mm</td>
<td>1 – 2 – 3 – 4 – 5 – 8 – 9</td>
</tr>
</tbody>
</table>

3.2 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.

3.2.1 Normal case

The normal case includes the load points 25 %, 50 %, 75 %, 100 % and 110 % of the maximum 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.

3.2.2 Emergency operation situations

For turbocharged engines the achievable output in case of turbocharger damage 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 has to state whether the achievable output is continuous. If there is a time limit, the permissible operating time is to be indicated.

3.3 Stage B - Type test

During the type test all the tests listed under 3.3.1 to 3.3.3 are to be carried out in the presence of the GL representative. The results achieved are to be recorded and signed by GL’s representative. Deviations from this program, if any, require the agreement of GL.

3.3.1 Load points

Load points at which the engine is to be operated are to conform to the power/speed diagram in Fig. 3.2.

The data to be measured and recorded when testing the engine at various load points has to 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 3.3.1.1 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.

3.3.1.1 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.

3.3.1.2 100 % power

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

3.3.1.3 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.

3.3.1.4 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

3.3.1.5 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 has to be adjusted corresponding to load points 9, 10 and 11.
3.3.2 Emergency operation

The maximum achievable power when operating in accordance with 3.2.2 has to be performed:

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

3.3.3 Functional tests

Functional tests to be carried out as follows:

- ascertainment of lowest engine speed according to the nominal propeller curve
- starting tests
- governor test
- test of the safety system particularly for overspeed and failure of the lubricating oil pressure
- test of electronic components and systems according to the test program approved by GL

3.4 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
- crank bearing and main bearing, dismantled
- cylinder liner in the installed condition
- cylinder head, valves disassembled
- camshaft, camshaft drive and crankcase with opened covers

Note

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

3.5 Type approval test report

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

3.6 Type approval Certificate

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

3.7 Type testing of mass produced engines

3.7.1 For engines with cylinder bores ≤ 300 mm which are to be manufactured in series the type test shall be carried out in accordance with GL Rules VI – Additional Rules and Guidelines, Part 4 – Diesel Engines, Chapter 1 – Guidelines for Mass Produced Engines.

3.7.2 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 requirements, the equipment may be demonstrated on another engine of the same series.

3.8 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 under GL supervision. 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.

Fig. 3.2 Power/speed diagram

- = Range of continuous operation
- = Range of intermittent operation
- = Range of short-time overload operation in special applications

Rated power
(continuous power)

Overload power

110 105.8

110 100 90 80 70 60 50 40 30 20 10 0

Speed [%] 100 90 80 70 60 50 40 30 20 10 0

Power [%] 110 105.8 100 90 80 70 60 50 40 30 20 10 0

Torque [%]

3 = Range of short-time overload operation in special applications
### Table 3.6 Pressure tests

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

---

1. In general, items are to be tested by hydraulic pressure as indicated in the Table. Where design or testing features may require modification of these test requirements, special consideration will be given.
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.

### 3.8.1 Main engines for direct propeller drive

The operation points have to be adjusted according to a) – e), functional tests have to be performed according to d) – f).

- **a)** 100 % power (rated power):
  - at 100 % engine speed (rated engine speed)
  - for at least 60 minutes after reaching the steady-state conditions

- **b)** 110 % power:
  - at 103 % engine speed
  - for 30 minutes after reaching the steady-state conditions

**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 A.3.4).

- **c)** 90 %, 75 %, 50 % and 25 % power in accordance with the nominal propeller curve
- **d)** starting and reversing manoeuvres, see H.2.4
- **e)** test of governor and independent overspeed protection device
- **f)** test of engine shutdown devices

### 3.8.2 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 steady-state condition
- **b)** 110 % power:
  - for 30 minutes after reaching the steady-state condition
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 A.3.5).

c) 75 %, 50 % and 25 % power and idle run
d) start-up tests, see H.2.4
e) test of governor and independent overspeed protection device
f) test of engine shutdown devices

3.8.3 Auxiliary driving engines and engines driving electric generators

The tests have to be performed according to 4.2.2.

For testing of diesel generator sets, see also Chapter 6 – Electrical Installations, Section 16.

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

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

3.11 Component inspection

After the test run randomly selected components shall be presented for inspection. The crankshaft deflection is to be checked.

4. Trials on installations/units (harbour and sea trials)

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

4.1 Scope of sea trials

4.1.1 Main propulsion engines driving fixed propellers of mobile offshore units

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 % engine speed:
   for 30 minutes
   where the engine adjustment permits, see A.3.4
c) determination of the minimum on-load speed.
d) starting manoeuvres, see H.2.4
e) in reverse direction of propeller rotation during the sea trials at a minimum speed of 70 % engine speed:
   for 10 minutes
f) testing of the monitoring and safety systems

4.1.2 Main propulsion engines driving controllable pitch propellers or reversing gears of mobile offshore units

4.1.1 applies as appropriate.

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

4.1.3 Main engines driving generators for propulsion of mobile offshore units

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

a) 100 % power (rated power):
   for at least 4 hours
   and
   at normal continuous cruise power:
   for at least 2 hours
b) 110 % power:
   for 30 minutes
c) in reverse direction of propeller rotation during the sea trials at a minimum speed of 70 % of the nominal propeller speed:
   for 10 minutes
d) starting manoeuvres, see H.2.4
e) testing of the monitoring and safety systems

Note

Tests are to be based on the rated powers of the driven generators.

4.1.4 Engines driving auxiliaries and electrical generators for mobile units and fixed installations

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 generating sets on board account shall be taken of the times needed to actuate the generator's overload protection system.

4.2 The suitability of main and auxiliary engines to burn special fuels is to be demonstrated if the machinery installation is designed to burn such fuels.

4.3 The scope of the trials on the installation/unit may be extended in consideration of special operating conditions such as low-load operation, towing, etc.

4.4 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.

F. Safety Devices

1. Speed control and engine protection against overspeed

1.1 Main and auxiliary engines

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

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 must 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 GL.

1.2 Engines driving electric generators

1.2.1 Each diesel engine used to drive an electric main or emergency generator has to 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 1.1.1.

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 overspeed protection device independent of the normal governor which prevents the engine speed from exceeding the rated speed by more than 15 %.

1.2.3 The diesel engine shall be suitable and designed for the special requirements of the electrical system of the unit/installation.

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 1.2.1 and 1.2.4.

Application of the load in more than two steps, see Fig. 3.3, is acceptable on condition that:

- the installation/unit'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 installation/unit's electrical system and is approved when the drawings are reviewed
- during trials on installations/units the functional tests are carried out without objections. Here the loading of the 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 installation/unit’s electrical system in the event of parallel generator operation and failure of a generator is to be demonstrated

1.2.4 Speed has to be stabilized and in steady-state condition within five seconds, inside the permissible range for the permanent speed variation \( \delta_T \). The steady-state condition is considered to have been reached when the residual speed variation does not exceed ±1 % of the speed associated with the set power.

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 Chapter 6 – Electrical Installations.

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. The start-up and loading sequence is to be concluded in about 30 seconds.

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

1.2.8 The governors of the engines mentioned in 1.2.1 have to enable the rated speed to be adjusted over the entire power range with a maximum deviation of 5 %.

1.2.9 The rate of speed variation of the adjusting mechanisms has to be permit satisfactory synchronization in a sufficiently short time. The speed characteristic should 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 1.1 and 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, work independently of the normal governor.

1.3 Use of electrical/electronic governors

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. For single propulsion drives 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.

The regulating conditions required for each individual application as described in 1.1 and 1.2 are to be satisfied by the governor system.

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

For the power supply, see Chapter 6 – Electrical Installations.

1.3.2 Requirements applying to main engines

For propulsion installations, 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 manoeuvring

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.

1.3.3 Requirements applying to auxiliary engines for driving electrical generators

Each auxiliary engine has to be equipped with its own governor system.

In the event of a fault in the governor system, the fuel admission in the injection pumps shall be set to "0".

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

1.3.4 The special conditions necessary to start operation from the dead ship condition are to be observed, see Chapter 6 – Electrical Installations.

2. Cylinder overpressure warning device

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.

2.2 A warning device may be dispensed with if it is ensured by an appropriate engine design or by control functions that the cylinder pressure cannot increase in an unacceptable range.

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**Fig. 3.3 Limiting curves for loading 4-stroke diesel engines step by step from no load rated power as function of the brake mean effective pressure**
3. Crankcase airing and venting

3.1 Crankcase airing
The airing of crankcases is not allowed.

3.2 Crankcase venting

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

3.2.2 Where provision has been made for forced extracting the lubricating oil vapours, e.g. for monitoring the oil vapour concentration, the negative pressure in the crankcase may not exceed 2.5 mbar.

3.2.3 The vent 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.

4. Crankcase safety devices

4.1 Crankcase safety devices have to be type approved.

4.2 Safety valves to safeguard against overpressure in the crankcase are to be fitted to all engines with a cylinder bore of > 200 mm and/or a crankcase volume of \( \geq 0.6 \text{ m}^3 \).

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 \( \text{ m}^3 \).

4.3 Engines with a cylinder bore of > 200 mm and \( \leq 250 \text{ mm} \) shall be equipped with at least one safety valve at each end of the crankcase. If the crankshaft has more than 8 throws, an additional safety valve is to be fitted near the middle of the crankcase.

Engines with a cylinder bore of > 250 mm and \( \leq 300 \text{ mm} \) shall have at least one safety valve close to every second crank throw, subject to a minimum number of two.

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

4.4 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 may not be less than 115 cm\(^2\) per m\(^3\) of crankcase gross volume.

Notes relating to 4.2 and 4.4

a) In estimating the gross volume of the crankcase, the volume of the fixed parts which it contains 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. In calculating the total free cross-sectional area, individual sections of < 45 cm\(^2\) are to be disregarded.

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

4.5 The safety devices are to be of quick acting and self closing type. In service they shall be oiltight when closed and shall prevent air from flowing into the crankcase. The gas flow caused by the response of the safety device shall be deflected, e.g. by means of a baffle plate, in such a way as not to endanger persons standing nearby.

Safety devices shall respond quickly and be fully opened at a differential pressure not greater than 0.2 bar.

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

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

4.8 A warning sign specifying that the crankcase doors and/or sight holes may not be opened immediately after stopping the engine, but only after a sufficient cooling period has elapsed, is to be mounted on the local engine control platform or, if appropriate, on both sides of the engine.

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

4.10 The oil mist monitoring and alarm information is to be capable of being read from a safe location away from the engine.

4.11 For multiple engine installations each engine is to be provided with a separate oil mist detection system and a dedicated alarm.

4.12 A copy of the documentation supplied with the oil mist detection system such as maintainance and test manuals are to be provided on board unit/installation.

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:

5.1 An isolation non-return valve is to be fitted to the starting air line serving each engine.
5.2 Engines with cylinder bores of > 230 mm are to be equipped with flame arrestors immediately in front of the intake of the main starting air line to each engine.

5.3 Equivalent safety devices may be approved by GL.

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.

7. Safety devices in scavenge air manifolds
The scavenge air manifolds in open connection to the cylinders are to be fitted with explosion relief valves as in 4.

G. Auxiliary Systems

1. General
For piping systems and accessory filter arrangements Section 13b is to be applied, additionally.

2. Fuel oil system

2.1 General

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

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 GL.

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.

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.

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 7.1. 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 are to be kept to a minimum.

2.2 Shielding

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
- efficiently monitored and alarmed

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

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

2.2.4 Where pipe sheaths in the form of hoses are provided as shielding, the hoses must be demonstrably suitable for this purpose and approved by GL.

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.

2.4 Heat tracing, thermal insulation, recirculation
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 heat tracing.

Means of fuel circulation are also to be provided.

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.

3. Filter arrangements for fuel and lubricating oil systems

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.

3.2 Where the arrangement stated in 3.1 is not feasible, the rotating parts and the hot components are to be sufficiently shielded.
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.

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.

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.

4. Lubricating oil system

4.1 General requirements relating to lubricating oil systems and to the cleaning, cooling, etc. of the lubricating oil are contained in Section 13e, E. For piping arrangement 2.1.3 is to be applied.

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 are to be provided for completely draining the oil sump.

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

4.1.3 Drain lines from the engine sump to the drain tank are to be submerged at their outlet ends.

4.2 The equipment of engines fitted with lubricating oil pumps is subject to Section 13b.

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.

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

4.2.3 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.

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 GL.

5. Cooling system

5.1 For the equipment of engines with cooling water pumps and for the design of cooling water systems, see Section 13e, F. – G.

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.

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.

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. Shut-off valves shall be provided enabling the main pumps to be isolated from the fresh cooling water system.

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.

5.3 Where engines are installed in spaces in which oil-firing equipment is operated, Sections 12a and 12d are also to be complied with.

6. Charge air system

6.1 Exhaust gas turbochargers

6.1.1 The construction and testing of exhaust gas turbochargers are subject to the requirements defined in Section 4.

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

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

6.1.4 Even at low engine speeds, main engines are to be supplied with charge air in a manner to ensure reliable operating.
6.1.5 If, in the lower speed range or when used for manoeuvring, 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.

6.1.6 With main engines emergency operation has to be possible in the event of a turbocharger failure.

6.2 Charge air cooling

6.2.1 The construction and testing of charge air coolers are subject to Section 12c – Pressure Vessels, Heat Exchangers and Filters.

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

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

7. Exhaust gas lines

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 material must be non-combustible.

7.2 General rules relating to exhaust gas lines are defined in Section 13e, N.

H. Starting Equipment

1. General

Engine starting equipment shall enable engines to be started up from the shutdown condition using only the means available on board.

2. Starting with compressed air

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 has to supply at least 50 % of the total capacity required.

2.2 The total capacity of the starting air compressors is to be such that the starting air receivers designed in accordance with 2.4 or 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 1.

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.

2.4 The total capacity of air receivers is to be sufficient to provide, without their being replenished, not less than six starts.

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

2.6 If starting air systems for auxiliaries or for supplying pneumatically operated regulating and manoeuvring equipment or tyfon 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.

2.7 Other consumers with a high air consumption apart from those mentioned in 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 GL.

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.

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 pressure.

2.10 For the approximate calculation of the starting air capacity, use may be made of the formula given in the Rules defined in L.

3. Electrical starting equipment

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 shall be sufficient for the execution within 30 minutes, without recharging the batteries, of the same number of start-up operations as is prescribed in 2.4 or 2.5 for starting with compressed air.
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 has to 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.

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

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

4. Start-up of emergency generating sets

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.

4.2 Each emergency generating set required to be capable of automatic starting is to be equipped with an automatic starting system approved by GL, the capacity of which is sufficient for at least three consecutive starts, compare Chapter 6 – Electrical Installations.

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.

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.

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.

4.5 Where direct manual starting is not possible, starting systems in accordance with 4.2 and 4.3 are to be provided, in which case the starting operation may be initiated manually.

4.6 The starters of emergency generator sets may be used only for the purpose of starting the emergency generator sets.

5. Start-up of emergency fire-extinguisher sets

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.

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 GL which enables at least 6 starts to be performed within 30 minutes, two of these being carried out within the first 10 minutes.

I. Control Equipment

1. General

For unmanned machinery installations Chapter 6 – Electrical Installations, Sections 9 and 12 are to be observed for automation in addition to the following requirements.

2. Main engines

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.
2.1.1 Indicators according to Table 3.7 are to be clearly sited on the local main engine control station.

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

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.

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

2.2 Machinery control room/control centre

For remotely operated or controlled machinery installations, the indicators listed in Table 3.7 are to be installed in the machinery control room, see also Chapter 6 – Electrical Installations.

2.3 Bridge/navigation centre

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

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

− speed of main engine
− speed/direction of rotation of shafting
− propeller pitch (controllable pitch propeller)
− starting air pressure (if applicable)
− control air pressure (if applicable)

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

3. Auxiliary engines

For auxiliary engines and emergency application engines the controls according to Table 3.7 are to be provided as a minimum.

J. Alarms

1. General

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

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.

2. Scope of alarms

Alarms have to be provided for main, auxiliary and emergency engines according to Table 3.7.

K. Engine Alignment/Seating

1. Engines are to be mounted and secured to their foundations in conformity with the GL Guidelines VI – Additional Rules and Guidelines, Part 4 – Diesel Engines, Chapter 3 – Guidelines for the Seating of Propulsion Plants and Auxiliary Machinery.

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 unit
− the condition of the engine - cold/preheated/hot

3. Where the engine manufacturer has not specified values for the permissible crank web deflection, assessment is to be based on GL’s reference values according to GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 2, K.4.

L. Approximate Calculation of the Starting Air Supply

This calculation shall follow the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 2, L.

M. Air Compressors

The requirements for design and construction of air compressors are defined in the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 2, M.
<table>
<thead>
<tr>
<th>Description</th>
<th>Propulsion engines</th>
<th>Auxiliary engines</th>
<th>Emergency engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed/direction</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine overspeed</td>
<td>A, S</td>
<td>A, S</td>
<td>A, S</td>
</tr>
<tr>
<td>Lubricating oil pressure at engine inlet</td>
<td>I, L, S</td>
<td>I, L, S</td>
<td>I, L</td>
</tr>
<tr>
<td>Lubricating oil temperature at engine inlet</td>
<td>I, H</td>
<td>I, H</td>
<td>I, H</td>
</tr>
<tr>
<td>Fuel oil pressure at engine inlet</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel oil leakage from high pressure pipes</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Cylinder cooling water pressure or flow at engine inlet</td>
<td>I, L</td>
<td>I, L, L</td>
<td>I, L, L</td>
</tr>
<tr>
<td>Cylinder cooling water temperature at engine outlet</td>
<td>I, H</td>
<td>I, H</td>
<td>I, H</td>
</tr>
<tr>
<td>Charge air pressure at cylinder inlet</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charge air temperature at charge air cooler inlet</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charge air temperature at charge air cooler outlet</td>
<td>I, H</td>
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</tr>
<tr>
<td>Starting air pressure</td>
<td>I, L</td>
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<td></td>
</tr>
<tr>
<td>Control air pressure</td>
<td>I, L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust gas temperature</td>
<td>I, H</td>
<td>I, H</td>
<td></td>
</tr>
<tr>
<td>Oil mist concentration in crankcase or alternative monitoring system</td>
<td>I, H</td>
<td>I, H</td>
<td>I, H</td>
</tr>
</tbody>
</table>

1 where ever the dimensions permit, at each cylinder outlet and at the turbo charger inlet and outlet
2 at turbocharger outlet only
3 cooling water pressure or flow
4 only for an engine output > 220 kW
5 for engines having an output > 2250 kW or a cylinder bore > 300 mm
6 alternative methods of monitoring may be approved by GL
7 an engine shutdown may be provided where necessary

I: Indicator
A: Alarm
H: Alarm for upper limit
L: Alarm for lower limit
S: Shutdown
Section 4

Gas Turbines and Exhaust Gas Turbochargers

A. Scope

1. Gas turbines
The documents for approval for main and auxiliary gas turbines have to be submitted to GL Head Office. The approval will be performed in accordance with GL Head Office.

2. Exhaust gas turbochargers
The detailed requirements for the Certification of exhaust gas turbochargers are defined in B. to E.

B. General Requirements for Exhaust Gas Turbochargers

1. Application
These rules are applicable for approval of exhaust gas turbochargers fitted on internal combustion/diesel engines and describe the required procedures for drawing approval, testing and Certification.

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 (MCR \(^1\) condition)

The maximum operational speed and the maximum permissible speed may be equal.

3. Type approval
In general turbochargers are type approved. A type approval Certificate valid for five (5) years will be documented and issued in accordance with 3.1.

3.1 Documentation to be submitted for type approval
For every turbocharger type, the documents listed below are to be submitted to GL in triplicate for type approval:

- cross-sectional drawings with main dimensions
- drawings of rotating part (shaft, turbine wheel, compressor wheel, blades) and details of blade fixing
- arrangement and flow diagram of lubrication system
- material specifications including their 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 authorised by the licensor to produce and deliver turbochargers of a certain type
- test report or verification by calculation of the containment test, carried out according to D.3.3.
- type test report carried out according to D.3.4

C. Design and Installation

1. General
The turbocharger is to be designed to operate at least under the conditions given in Section 1, C.

---

\(^1\) MCR = maximum continuous rating
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.

The turbocharger rotors need to be designed according to the speed criteria for natural burst. 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 overspeed after compressor burst due to loss of energy absorption in the compressor.

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.

4. Hot surfaces

According to SOLAS Rules and Regulations, Chapter II-2, Part B – Prevention of fire and explosion, Regulation 4, Paragraph 2.3, 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 leakage oil either spraying or dripping 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.

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.

6. 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 GL approved manufacturers according to the previously approved drawings and material specifications. The manufacturer shall be recognized by the holder of the original type approval.

D. Tests

1. Material tests

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 GL. According to the decision of GL, 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 expertise of independent testing bodies.

The turbocharger casings are to be from ductile materials (min. 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 GL.

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 Certificates. The final verification of material properties for components needs to be adapted and co-ordinated according to production procedure. Deviations from the heat treatment procedures have to be approved by GL separately.

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 GL Rules II - Materials and Welding, Part 1- Metallic Materials or, where applicable, in the relevant maker’s specifications approved in connection with the design in each case.
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.

1.5 **GL 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 technology, melt 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 test Certificates are to be be issued by the manufacturer or GL. The required Certificates are indicated in Table 4.1.

The materials are to conform to specifications approved in connection with the type approval in each case. For material tests see also the Rules II – Materials and Welding.

2. **Testing of components**

2.1 **General**

The following tests as outlined in 2.2 to 2.4 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 GL Surveyor for examination.

GL reserve the right to review the proper performance and the results of the tests at any time to the satisfaction of the GL Surveyor.

2.2 **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 $p_p = 4$ bar, but not less than $p_p = 1.5 \times p_c$ ($p_p$ : test pressure; $p_c$ : design pressure).

2.3 **Overspeed test**

All wheels (compressor and turbine) have to undergo an overspeed 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 GL approved non-destructive testing method no overspeed test is required. Deviations are to be approved separately by GL.

<table>
<thead>
<tr>
<th>Turbocharger components</th>
<th>Type of Certificates ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft</td>
<td>GL Material Certificate</td>
</tr>
<tr>
<td>Rotors (compressor and turbine)</td>
<td></td>
</tr>
<tr>
<td>Blades</td>
<td>Manufacturer Inspection Certificate</td>
</tr>
<tr>
<td>Casing</td>
<td>GL Material Certificate</td>
</tr>
</tbody>
</table>

¹ Certificates are to be issued in accordance with GL Rules II – Materials and Welding, Part 1 – Metallic Materials, Chapter 1 – Principles and Test Procedures, Section 1, H.
2.4 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 or comparable regulations may be referred to.

3. Testing of turbochargers

3.1 General

The tests as specified in 3.2 to 3.4 are to be performed in presence of a GL Surveyor. The tests 3.3 and 3.4 are only to be executed during the type approval procedure.

3.2 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 GL Surveyor for inspection based upon an agreed spot check basis.

If the manufacturer is approved as a manufacturer of mass produced turbochargers according to E.2., the bench test can be carried out on an agreed sample basis. In this case the GL Surveyor’s attendance at the test is not required.

3.3 Containment test

The turbocharger has to fulfil 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 a type approval 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 speed of compressor and turbine has 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 in lieu of the practical containment test, 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 must be proven for the worst case.

In general a GL Surveyor or the Head Office shall be involved for the containment test. The documentation of the physical containment test as well as the report of the simulation results shall be submitted to GL within the scope of the approval procedure.

3.4 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).
E. Shop Approvals

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 GL.

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 GL approved mass produced diesel engines having a cylinder bore of $\leq 300$ mm may apply for the shop approval by GL Head Office.

Upon satisfactory shop approval, the material tests according to D.1. for these parts may be covered by a Manufacturer Inspection Certificate and need not to be verified by a GL Surveyor.

In addition the bench test according to D.3.2 may be carried out on a sample basis and need not to be verified by a GL Surveyor.

The shop approval is valid for 3 years with annual follow up audits.

No GL 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.

3. Manufacturing of exhaust gas turbochargers under license agreement.

Manufacturers who are manufacturing exhaust gas turbochargers under a license agreement shall have a shop approval of GL Head Office.

The shop approval can be issued in addition to a valid license agreement if the following requirements are fulfilled:

- The manufactured turbochargers have a valid GL type approval 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 type approval for the licensor.

Upon satisfactory assessment in combination with a bench test carried out on a sample basis with GL Surveyor's attendance, the drawing approval and tests according to D.3.3 and D.3.4 are not required.

The scope of the testing for materials and components has to be fulfilled unchanged according to D.2.2 to D.2.4 and D.3.2.

The shop approval is valid for three (3) years with annual follow up audits and can be granted, if required in combination with an approval as manufacturer of mass-produced turbochargers.

The approval becomes invalid if the licence agreement expires. The licensor is obliged to inform the GL Head Office about the date of expiry.
Section 5

Gears, Couplings

A. General

1. Scope

1.1 These requirements apply to spur, planetary and bevel gears, intermediate shafts and to all types of couplings for incorporation in the propulsion plant of mobile units or essential auxiliary machinery as specified in Section 1, H.

1.2 Application of these requirements to auxiliary machinery couplings may generally be restricted to basic approval by GL of the particular coupling type. Regarding the design of elastic couplings for use in generator sets, reference is made to G.2.6.

2. Documents for approval

Assembly and sectional drawings together with the necessary detail drawings and parts lists are to be submitted to GL in triplicate for approval. They shall contain all the data necessary to enable the load calculations to be checked.

B. Materials

1. Approved materials

1.1 Shafts, pinions, wheels and wheel rims of gears in the main propulsion plant shall preferably be made of forged steel. Rolled steel bar may also be used for plain, flangeless shafts. Gear wheel bodies may be made of grey cast iron or nodular cast iron, or may be fabricated from welded steel plate with steel or cast steel hubs.

1.2 Couplings in the main propulsion plant of mobile offshore units have to be made of steel, cast steel or nodular cast iron with a mostly ferritic matrix. Grey cast iron or suitable cast aluminium alloys may be permitted for lightly stressed external components and casings of hydraulic slip couplings.

1.3 The gears of essential auxiliary machinery according to Section 1, H. are subject to the same requirements as those specified in 1.1 as regards the material used. For gears intended for auxiliary machinery other than that mentioned in Section 1, H. other materials may be permitted.

1.4 Flexible coupling bodies for essential auxiliary machinery may generally be made of grey cast iron; for the outer coupling bodies a suitable aluminium alloy may also be used. For generator sets, however, use shall only be made of coupling bodies made of nodular cast iron with a mostly ferritic matrix, of steel or of cast steel, to ensure that the couplings are well able to withstand the shock torques occasioned by short circuits. GL reserve the right to impose similar requirements on the couplings of particular auxiliary drive units.

2. Testing of materials

All gear and coupling components which are involved in the transmission of torque and which are intended for the main propulsion plant have to be tested in accordance with the GL Rules II – Materials and Welding. The same applies to the materials used for gear components with a major torque transmission function and for generator couplings in generator drives. Suitable documentation is to be submitted for the materials used for the major components of the couplings and gears of all other functionally essential auxiliary machines. This documentation may take the form of a GL Material Test Certificate or an acceptance test Certificate issued by the steelmaker.

C. Calculation of the Load-Bearing Capacity of Gear Teeth

1. Proof of sufficient mechanical strength of the roots and flanks of gear teeth has to be submitted to GL for the intended load of the gear.

2. Calculations of tooth root bending stress and flank contact stress are to be performed according to the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2, Section 5, C. or other internationally accepted standards.

For the offshore industry special calculation parameters have to be used, where appropriate. The values to be used for the minimum safety margins $S_0$ and $S_0$ as well as the application factor $K_A$ are defined in Tables 5.1 and 5.2.
Table 5.1 Minimum safety margins for flank and root bending stress

<table>
<thead>
<tr>
<th>Case</th>
<th>Application</th>
<th>Boundary condition</th>
<th>$S_H$</th>
<th>$S_F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td></td>
<td>Modulus $m_n \leq 16$ $^3$</td>
<td>1.3</td>
<td>1.8</td>
</tr>
<tr>
<td>1.2</td>
<td>Gearing in propulsion systems for units and generator drive systems</td>
<td>Modulus $m_n \leq 16$ $^3$</td>
<td>$0.024 \cdot m_n + 0.916$</td>
<td>$0.02 \cdot m_n + 1.48$</td>
</tr>
<tr>
<td>1.3</td>
<td></td>
<td>In case of two mutually independent main propulsion systems up to an output torque of 8000 Nm</td>
<td>1.2</td>
<td>1.55</td>
</tr>
<tr>
<td>Auxiliary systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Gears in auxiliary drive systems used which are subjected to dynamic load</td>
<td></td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>2.2</td>
<td>Gears in auxiliary drive systems used for dynamic positioning (Class Notations DP1 – DP3)</td>
<td></td>
<td>1.3</td>
<td>1.8</td>
</tr>
<tr>
<td>2.3</td>
<td>Gears in auxiliary drive systems which are subjected to static load</td>
<td>$N_L \leq 10^4$ $^4$</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2.4</td>
<td>Winches for positional mooring</td>
<td></td>
<td>1.2</td>
<td>1.55</td>
</tr>
<tr>
<td>2.5</td>
<td>Jacking systems</td>
<td></td>
<td>1.2</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Note:

1 $S_H$ = safety factor against pittings [-]
2 $S_F$ = safety factor against tooth breakage [-]
3 $m_n$ = normal module [mm]
4 $N_L$ = number of load cycles [-]

If the fatigue bending stress of the tooth roots is increased by technique approved by GL, e.g. by shot peening for case-hardened toothing with modulus $m_n \leq 10$ the minimum safety margin $S_F$ may be reduced up to 15 % with the consent of GL.

D. Gear and Intermediate Shafts

1. Minimum diameter

The dimensions of shaft sections for reversing and reduction gears as well as intermediate shafts are to be calculated by applying the following formula:

$$d \geq F \cdot k \cdot \sqrt[3]{\frac{P}{n \cdot \left[1 - \left(\frac{d_i}{d_a}\right)^4\right] \cdot C_w}}$$

For $\frac{d_i}{d_a} \leq 0.4$ the expression $\left[1 - \left(\frac{d_i}{d_a}\right)^4\right]$ may be set to 1.0.

$F$ = factor for the type of drive [-]:
- 95 for turbine plants, electrical drives and internal combustion engines with slip couplings
- 100 for all other types of drive.

$P$ = driving power of shaft [kW]

$n$ = shaft speed [min$^{-1}$]

$d_i$ = diameter of shaft bore, if applicable [mm]

$d_a$ = actual shaft diameter [mm]
### Table 5.2 Application factor $K_A$

<table>
<thead>
<tr>
<th>System type</th>
<th>$K_A$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main systems</strong></td>
<td></td>
</tr>
<tr>
<td>Turbines and electric drive systems</td>
<td>1,1</td>
</tr>
<tr>
<td>Diesel engine drive systems with fluid clutch between engine and gears</td>
<td>1,1</td>
</tr>
<tr>
<td>Diesel engine drive systems with highly flexible coupling between engine and gears</td>
<td>1,3</td>
</tr>
<tr>
<td>Diesel engine drive systems with no flexible coupling between engine and gears</td>
<td>1,5</td>
</tr>
<tr>
<td>Generator drives</td>
<td>1,5</td>
</tr>
<tr>
<td><strong>Auxiliary systems</strong></td>
<td></td>
</tr>
<tr>
<td>Thruster with electric drives</td>
<td>1,1 (20000 h) 1</td>
</tr>
<tr>
<td>Thruster drives with diesel engines</td>
<td>1,3 (20000 h) 1</td>
</tr>
<tr>
<td>Windlasses</td>
<td>0,6 (300 h) 1</td>
</tr>
<tr>
<td></td>
<td>2,0 (20 h) 2</td>
</tr>
<tr>
<td>Combined anchor and mooring winches</td>
<td>0,6 (1000 h) 1</td>
</tr>
<tr>
<td></td>
<td>2,0 (20 h) 2</td>
</tr>
<tr>
<td>Winches for positional mooring</td>
<td>1,1 (20000 h)</td>
</tr>
<tr>
<td>Jacking system during elevating</td>
<td>1,5 (1000 h)</td>
</tr>
<tr>
<td>Jacking system under static load</td>
<td>0,7 (20000 h)</td>
</tr>
</tbody>
</table>

1 Assumed running hours for low cycle layout
2 Assumed maximum torque for windlasses
For other types of systems $K_A$ is to be stipulated separately.

$C_W = \text{material factor } [-] = \frac{560}{(R_m + 160)}$

$R_m = \text{tensile strength of shaft material } [\text{N/mm}^2]$  
For wheel shafts the value of $R_m$ in the formula shall not be higher than 800 N/mm². For pinion shafts the actual tensile strength value may generally be substituted for $R_m$  
For gear shafts:

- $k = \text{factor for type of shaft } [-]$  
  - 1,10 for plain shaft sections and thrust shafts  
  - 1,15 for shafts in the area of the pinion or wheel body if this is keyed to the shaft, and for multiple-spline shafts  

For intermediate shafts:

$k = 1,0$ for plain sections not exposed to bending with integral forged or shrink fitted keyless coupling flanges  
- 1,10 for intermediate shaft sections in way of key and at distance of at least 0,2 d from the ends of the keyway  
- 1,10 for intermediate shaft sections with radial holes of a diameter not greater than 0,3 d  
- 1,15 for intermediate shaft sections designed as multi-splined shafts where d is the outside diameter of the splined shaft  

Higher values of $k$ may be specified by GL where increased bending stresses in the shaft are liable to occur because of the bearing arrangement, the casing design and the tooth pressure, etc.
E. Equipment

1. Oil level indicator

For monitoring the lubricating oil level in main propulsion and auxiliary gears, equipment has to be fitted to enable the oil level to be determined.

2. Pressure and temperature control

Temperature and pressure gauges have to be fitted to monitor the lubricating oil pressure and the lubricating oil temperature at the oil-cooler outlet before the oil enters the gear.

Plain journal bearings are also to be fitted with temperature indicators.

Where gears are fitted with anti-friction bearings, an indicator is to be mounted at a suitable point to show the temperature of the oil. For gears rated up to 2000 kW, special arrangements may be agreed with GL.

Where mobile offshore units are equipped with automated machinery, the requirements of Chapter 6 – Electrical Installations have to be considered.

3. Lubricating oil pumps

Lubricating oil pumps driven by the gearing must be mounted in such a way that they are accessible and can be replaced.

4. Gear casings

The casings of gears belonging to the main propulsion plant and to essential auxiliaries have to be fitted with removable inspection covers to enable the toothing to be inspected, the thrust bearing clearance to be measured and the oil sump to be cleaned.

5. Seating of gears

The seating of gears on steel or cast resin chocks is to conform to the GL Rules VI – Additional Rules and Guidelines, Part 4 – Diesel Engines, Chapter 3 – Guidelines for the Seating of Propulsion Plants and Auxiliary Machinery.

In the case of cast resin seatings, the thrust shall be absorbed by means of stoppers. The same applies to cast resin seatings of separate thrust bearings.

F. Balancing and Testing

1. Balancing

1.1 Gear wheels, pinions, shafts, gear couplings and, where applicable, high-speed flexible couplings have to be assembled in properly balanced condition.

1.2 The generally permissible residual imbalance $U$ per balancing plane of gears, for which static or dynamic balancing is rendered necessary by the method of manufacture and by the operating and loading conditions, can be determined by applying the formula:

$$U = \frac{9.6 \cdot Q \cdot G}{z \cdot n} \quad [\text{kgmm}]$$

$G$ = mass of body to be balanced [kg]

$n$ = operating speed of body to be balanced [rev./min]

$z$ = number of balancing planes [-]

$Q$ = degree of balance [-]:

= 6.3 for gear shafts, pinions and coupling members for engine gears

= 2.5 for torsion shafts and gear couplings, pinions and gear wheels belonging to turbine transmissions.

2. Testing of gears

2.1 Testing in the manufacturer’s works

When the testing of materials and components has been carried out, gearing systems are to be presented to GL for final inspection and operational testing in the manufacturer’s works. For the inspection of welded gear casings, see GL Rules II – Materials and Welding, Part 3 – Welding, Chapter 3 – Welding in the Various Fields of Application.

The final inspection is to be combined with a trial run lasting several hours under part or full-load conditions; on this occasion the tooth clearance and contact pattern are to be checked. In the case of a trial at full-load, any necessary running-in of the gears shall have been completed beforehand.

Where no test facilities are available for the operational and on-load testing of large gear trains, these tests may also be performed after installation of the unit or fixed offshore installation.

Tightness tests are to be performed on those components to which such testing is appropriate.

Reductions in the scope of the test require the consent of GL.

2.2 Tests during commissioning trials

2.2.1 Prior to the start of commissioning trials, the teeth of the gears belonging to the main propulsion plant are to be coloured with suitable dye to enable the contact pattern to be checked. During the commissioning trials, the gears are to be checked at all forward and reverse speeds to establish their operational efficiency and smooth running as well as the bearing temperatures and the freedom from contamination of the lubrication oil.
At the latest on conclusion of the commissioning trials, the gearing is to be examined via the inspection openings and the contact pattern checked. Assessment of the contact pattern is to be based on the guide values for the proportional area of contact in the axial and radial directions of the teeth given in Table 5.3 and shall take account of the running time and loading of the gears during the commissioning trials.

2.2.2 In the case of multistage gear trains and planetary gears manufactured to a proven high degree of accuracy, checking of the contact pattern after commissioning trials may, with the consent of GL, be reduced in scope.

G. Design and Construction of Couplings

1. Tooth couplings

1.1 Adequate loading capacity of the tooth flanks of straight-flanked tooth couplings requires that the following conditions be satisfied:

$$p = 2.55 \cdot 10^4 \cdot \frac{P \cdot K_A}{b \cdot h \cdot d \cdot z \cdot n}$$

where:

- $p$ = actual contact pressure of the tooth flanks [N/mm²]
- $P$ = driving power at coupling [kW]
- $d$ = pitch circle diameter [mm]
- $K_A$ = application factor according to Table 5.2
- $z$ = number of teeth [-]
- $n$ = speed [rev./min]
- $h$ = working depth of tooth [mm]
- $b$ = load-bearing tooth width [mm]

The coupling teeth are to be effectively lubricated. For this purpose a constant oil level maintained in the coupling may generally be regarded as adequate where

$$d \cdot n^2 < 6 \cdot 10^9 \text{ [mm/min²]}$$

For higher values of $d \cdot n^2$, couplings in main propulsion plants are to be provided with a forced circulation system of lubrication.

1.3 For the dimensional design of the sleeves, flanges and bolts of gear couplings the formulae given in 3. are to be applied.

<table>
<thead>
<tr>
<th>Material, manufacturing of toothing</th>
<th>Working tooth depth (without tip relief)</th>
<th>Width of tooth (without end relief)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat-treated, hobbed, formed by generating method</td>
<td>33 % average</td>
<td>70 %</td>
</tr>
<tr>
<td>Surface-hardened, ground, shaved</td>
<td>40 % average</td>
<td>80 %</td>
</tr>
</tbody>
</table>
2. Flexible couplings

2.1 Flexible couplings shall be approved for the loads specified by the manufacturer and for use in propulsion plants and essential auxiliary machinery.

2.2 Flexible couplings for propulsion plants and in generator sets shall be so dimensioned that they are able to withstand, for a reasonable time, operation with one engine cylinder out of service.

2.3 With regard to the routine supervision of coupling types already approved by GL and in order to prove adequate dynamic fatigue strength prior to the issue of a general type approval for flexible couplings to be introduced into the offshore industry for the first time, GL reserve the right to call for the execution of special dynamic loading tests appropriate to the design of the coupling in question.

2.4 With regard to the casings, flanges and bolts of flexible couplings, the requirements specified in 3. are to be complied with.

2.5 If, when subjected to load during operation, a flexible coupling is so designed that it exerts an axial thrust on the coupled members of the driving mechanism, provision has to be made for the absorption of this thrust.

2.6 Flexible couplings for diesel generator sets have to be capable of absorbing impact moments due to electrical short circuits up to 6 times the nominal torque of the coupling.

3. Flange and clamp-type couplings

3.1 Definitions

In the following formulas the defined symbols are used:

- \( d \) = shaft diameter in area of clamp-type coupling [mm]
- \( d_S \) = diameter of fitted bolts [mm]
- \( d_k \) = thread core diameter of plain bolts [mm]
- \( D \) = diameter of pitch circle of bolts [mm]
- \( n \) = shaft speed [min⁻¹]
- \( P_W \) = power transmitted by shaft [kW]
- \( z \) = number of fitted or plain bolts [-]
- \( R_m \) = tensile strength of fitted or plain bolt material [N/mm²]

3.2 Coupling flanges

The thickness of coupling flanges of intermediate and thrust shafts must be not less than 20 % of the Rule diameter according to D.1.

The thickness of mentioned flanges may not be less than the Rule diameter of the fitted bolts, as far as their calculation is based on the same material tensile strength as applied for the shafting.

For coupling flanges of propeller shafts of units see Section 6, A.2.

3.3 Bolts

3.3.1 The bolts used to connect flange couplings are normally to be designed as fitted bolts. The minimum diameter \( d_S \) of fitted bolts at the coupling flange faces is to be determined by applying the formula:

\[
d_S = 16 \cdot \sqrt[6]{\frac{10^6 \cdot P_W}{(n \cdot D \cdot z \cdot R_m)}} [\text{mm}]
\]

The nuts of coupling bolts are to be secured.

3.3.2 Where, in special circumstances, the use of fitted bolts is not feasible, GL may accept application of an equivalent connection with comparable capacity based on frictional force transmission only.

3.3.3 The minimum thread root diameter \( d_k \) of the connecting bolts used for clamp-type couplings is to be determined using the formula:

\[
d_k = 12 \cdot \sqrt{\frac{10^6 \cdot P_W}{(n \cdot d \cdot z \cdot R_m)}} [\text{mm}]
\]

3.3.4 The shank of necked-down bolts shall be not less than 0.9 times the thread root diameter. If, besides the torque, the bolted connection is also required to transmit considerable additional forces, the size of the bolts has to be increased accordingly.

4. Shrink-fitted couplings

4.1 Definitions

- \( A \) = effective area of shrink-fit seating [mm²]
- \( c_A \) = coefficient for shrink-fitted joints [-], depending on the kind of driving unit
  - 1.0 for geared diesel engine and turbine drives
  - 1.2 for direct diesel engine drives
- \( C \) = conicity of shaft ends [-]
- \( f \) = difference in taper diameters / length of taper
- \( Q \) = peripheral force at the mean joint diameter of a shrink fit [N]
- \( S \) = safety factor against slipping of shrink fits in the shafting [-]
  - 3.0 between motor and gearing
  - 2.5 for all other applications
- \( T \) = propeller thrust in [N]
- \( \mu_0 \) = coefficient of static friction [-]:
≤ 0,15 for hydraulic shrink fits
≤ 0,18 for dry shrink fits

Θ = half taper of shaft ends [-]
= C / 2

4.2 Where shafts are connected by keyless shrink fitted couplings (flange or sleeve type), the dimensioning of these shrink fits should be chosen in a way that the maximum von Mises equivalent stress in all parts will not exceed 80 % of the yield strength of the specific materials during operation and 95 % during mounting and dismounting.

For the calculation of the safety margin of the connection against slippage, the maximum (theoretical) clearance will be applied, derived as the difference between the lowest respectively highest still acceptable limit of the applied nominal tolerance field for the bore and the shaft. The contact pressure \( p \) [N/mm²] in the shrunk-on joint to achieve the required safety margin may be determined by applying the two following formulae.

\[
p = \frac{\sqrt{\Theta^2 \cdot T^2 + f \cdot (C^2 \cdot Q^2 + T^2)} \pm \Theta \cdot T}{A \cdot f} \quad [N/mm^2]
\]

"+" sign following the root applies to conical shrunk joints without an axial stop to absorb astern thrust.

"−" sign following the root if the conical shrunk joint has an axial stop to absorb astern thrust.

\[
f = \left( \frac{H_0}{S} \right)^2 - \Theta^2
\]

5. Testing

Couplings for propulsion plants and couplings for generator sets and transverse thrusters are to be presented to GL for final inspection and, where appropriate, for the performance of functional and tightness tests.
Section 6

Propulsion Systems

A. Main Propulsion System

1. Scope
As main propulsion system of a mobile offshore unit the following arrangement shall be understood:
- driving source in form of an internal combustion engine, gas turbine or steam turbine
- couplings
- reduction gear, if applicable
- main shafting including its bearings
- propeller
- rudder
- steering gear
For this system also the torsional vibrations have to be investigated.

2. References
As the elements of the system described in 1. are identical to the systems used on seagoing merchant ships the requirements for their Classification or Certification are not fully defined in these Rules, but are also referred to the GL Rules I – Ship Technology, Part 1 – Seagoing Ships. The following references can be given:
- internal combustion engines, see Section 3
- steam turbines according to GL Rules I – 1 – 2, Section 3a
- gas turbines, see Section 4
- couplings see Section 5, G.
- gears, see Section 5, A. – F.
- main shafting according to GL Rules I – 1 – 2, Section 4
- propeller according to GL Rules I – 1 – 2, Section 6
- rudder according to GL Rules I – 1 - 1, Section 14
- steering gear according to GL Rules I – 1 – 2, Section 14, A.
- torsional vibrations, see Section 7

B. Rudder Propellers

1. General

1.1 Definition
The rated power of rudder propellers is transmitted to the propeller via a rotating shaft, vertically to the propeller shaft and a gear situated in an underwater housing. This housing is turnable and therefore the steering effect is achieved by changing the direction of the propeller thrust.

1.2 Scope
The requirements of B. apply to rudder propellers as main and auxiliary drive for mobile offshore units, the unit’s manoeuvring station and all transmission elements from the manoeuvring station to the rudder propeller.

For the electrical equipment see Chapter 6 – Electrical Installations, Section 12, B.

1.3 Documents for approval
Assembly and sectional drawings as well as part drawings of the gears and propellers giving all the data necessary for examination are to be submitted to GL in triplicate for approval.

2. Materials

2.1 Approved materials

2.1.1 As a rule, important load-transmitting components shall be made of steel or cast steel complying with the GL Rules II – Materials and Welding, Part 1 – Metallic Materials.

With the consent of GL, cast iron may be used for certain components.

Pressure vessels shall in general be made of steel, cast steel or nodular cast iron (with a predominantly ferritic matrix).

For welded structures, the GL Rules II – Materials and Welding, Part 3 - Welding are to be observed.

For gear materials see Section 5, B.1, for propeller materials see A.2.
2.1.2 Casings with house journal and guide bearings on units with nozzle rudder and ice class are not to be made of grey cast iron.

2.1.3 The pipes of the hydraulic system are to be made of seamless or longitudinally welded steel tubes. The use of cold-drawn, unannealed tubes is not permitted.

At points where they are exposed to damage, copper pipes for control lines are to be provided with protective shielding and are to be safeguarded against hardening due to vibration by the use of suitable fastenings.

2.1.4 High-pressure hose assemblies may be used for short pipe connections subject to compliance with Section 13d, if this is necessary due to vibrations or flexibly mounted units.

2.1.5 The materials used for pressurized components including the seals shall be suitable for the hydraulic oil in use.

2.2 Testing of materials

All important components of the rudder propeller involved in the transmission of torque and bending moments have to be tested under supervision of GL in accordance with the GL Rules II – Materials and Welding, Part 1 – Metallic Materials.

3. Design and equipment

3.1 Number of rudder propellers

Each unit shall have at least two rudder propellers if used as main drive. The rudder propellers shall be capable of being operated independently of the other.

3.2 Locking devices

Each rudder propeller is to be provided with a locking device to prevent the unintentional rotation of the propeller and the turning mechanism of the rudder propeller which is out of service at any time. If used as main drive, it shall be possible to operate the unit with all remaining power at a sufficient speed for safe operation, without any problems at the locking devices.

3.3 Controls

3.3.1 Both the drive and the turning mechanism of each rudder propeller shall be controlled from a manoeuvring station on the navigating bridge.

The controls shall be mutually independent and so designed that the rudder propeller cannot be shifted unintentionally.

An additional combined control for all rudder propellers is permitted.

The steering angle of the rudder propellers shall be restricted to a predefined working range. This may be dispensed with in cases where no danger for the unit is caused by unintentional turning of the rudder propellers at full power and unit speed to any angle.

3.3.2 The failure of a single element within the control and hydraulic system of one rudder propeller, shall not lead to the failure of the other rudder propellers.

3.3.3 An auxiliary steering device has to be provided for each rudder propeller. In case of a failure of the main steering system of a main drive, the auxiliary steering device shall at least be capable of moving the rudder propeller to midship position.

3.3.4 Where the hydraulic systems of more than one rudder propeller are combined, it shall be possible in case of a loss of hydraulic oil to isolate the damaged system in such a way that the other control systems remain fully operational.

3.4 Position indicators

3.4.1 The position of each rudder propeller shall be clearly discernible on the navigating bridge and at each manoeuvring station.

3.4.2 The actual position shall also be discernible at the rudder propeller itself.

3.5 Pipes

3.5.1 The pipes of rudder propeller systems are to be installed in such a way as to ensure maximum protection while remaining readily accessible.

Pipes are to be installed at a sufficient distance from the units’ shell. As far as possible, pipes should not pass through working spaces.

Connections to other hydraulic systems are not permitted.

3.5.2 For the design and dimensions of pipes, valves, fittings, pressure vessels etc., see Section 12c – Pressure Vessels, Heat Exchangers and Section 13d – General Design of Piping Systems.

3.6 Oil level indicators, filters

3.6.1 Tanks within the hydraulic system are to be equipped with oil level indicators.

3.6.2 The lowest permissible oil level is to be monitored. Audible and visual alarms shall be given on the navigating bridge and in the machinery space. The alarm on the navigating bridge shall be an individual alarm.

3.6.3 Filters for cleaning the operating fluid are to be located in the piping system.
3.7 Lubrication

3.7.1 The lubricating oil supply is to be ensured by a main pump and an independent standby pump.

3.7.2 In the case of a separate lubricating system in which the main lubricating oil pumps can be replaced with the means available on board, complete standby pumps ready for mounting may be carried on board.

4. Design

4.1 Gears

For the design of gears see Section 5. The turning gears are in general to take form of spur gears or bevel gears.

4.2 Shaft line

For the design of the propeller shaft, between propeller and gear wheel, see A.2. For the design of the remaining part of this shaft and all other shafts see Section 5, D.1.

4.3 Propellers

For the design of propellers see A.2.

4.4 Support pipe

The dimensional design of the support pipe and its attachment to the unit’s hull shall take account of the loads due to the propeller and nozzle thrust including dynamic components.

4.5 Pipes

The arrangement and design of pipes, valves, fittings and pressure vessels see Section 13d and Section 12c.

5. Tests in the manufacturer's work

5.1 Testing of power units

The power units are required to undergo tests on a test stand in the manufacturer’s works.

5.1.1 For diesel engines, see Section 3.

5.1.2 For electric motors, see Chapter 6 – Electrical Installations, Section 15.

5.1.3 For hydraulic pumps and motors the GL Rules VI – Additional Rules and Guidelines, Part 6 – Pumps – Compressors – Fittings, Chapter 1 – Guidelines for the Design, Construction and Testing of Pumps are to be applied analogously. Where the drive power is 50 kW or more the testing is to be carried out in the presence of a GL Surveyor.

5.2 Pressure and tightness tests

Pressure components are to undergo a pressure test. The test pressure is \( p_p \):

\[
p_p = 1.5 \cdot p_c
\]

\( p_c \) = design pressure = maximum allowable working pressure [bar] = the pressure at which the relief valves open. However, for working pressures above 200 bar the test pressure need not exceed \( p + 100 \) bar.

For pressure testing of pipes, their valves and fittings, see Section 13d.

Tightness tests are to be performed on components to which this is appropriate.

5.3 Final inspection and operational testing

5.3.1 After inspection of the individual components and completion of assembly, rudder propellers are to undergo a final inspection and operational test. The final inspection shall be combined with a trial run lasting several hours under part or full-load conditions. A check is to be carried out on the tooth clearance and contact pattern.

5.3.2 When no suitable test bed is available for the operational and load testing of large rudder propellers, the tests mentioned in 5.3.1 can be carried out on the occasion of the dock test.

5.3.3 Limitations on the scope of the test require GL’s consent.

6. Testing on board

6.1 All drives

The faultless operation, smooth running and bearing temperatures of the gears and control system are to be checked during the sea trials under all steaming conditions.

6.2 Main drives

After the conclusion of the sea trials, the toothing is to be examined through the inspection openings and the contact pattern is to be checked. The tooth contact pattern is to be assessed on the basis of the reference values for the percentage area of contact given in Section 5, Table 5.3.

The scope of the check on contact pattern following the sea trials may be limited with the Surveyor’s agreement provided that the checks on contact pattern called for in 5.3.1 have proved satisfactory.

C. Lateral Thrust Units

1. General

1.1 Scope

The requirements contained in C apply to the lateral thrust unit, the manoeuvring station and all the transmission elements from the manoeuvring station to the lateral thrust unit.
1.2 Documents for approval

Assembly and sectional drawings for lateral thrust units with an input power of 100 kW and more together with detail drawings of the gear mechanism and propellers containing all the data necessary for checking are each to be submitted to GL in triplicate for approval. In the case of propellers, this only applies to propulsive power levels above 500 kW.

2. Materials

Materials are subject, as appropriate, to the provisions of Section 5, B.

A.2. applies analogously to the materials and the material testing of propellers.

3. Dimensioning and design

3.1 The design of the relevant components of lateral thrust units shall be in accordance with Section 5 for gears and shafting, that of propellers with A.2.

3.2 The pipes of hydraulic lateral thrust units are to be made of seamless or longitudinally welded steel tubes. The use of cold-drawn, unannealed tubes is not permitted.

At points where they are exposed to damage, copper pipes for control lines are to be provided with protective shielding and are to be safeguarded against hardening due to vibration by the use of suitable fastenings.

High pressure hose assemblies may be used for short pipe connections subject to compliance with Section 13d, if this is necessary due to vibrations or flexibly mounted units.

3.3 Lateral thrust units shall be capable of being operated independently of other connected systems.

3.4 Windmilling of the propeller during sea passages has to be taken into account as an additional load case. Otherwise effective countermeasures have to be introduced to avoid windmilling, e.g. a shaft brake.

3.5 In the propeller area the thruster tunnel shall be protected against damages caused by cavitation corrosion by effective measures, such as stainless steel plating.

3.6 For the electrical equipment of lateral thrust units, see Chapter 6 - Electrical Installations, Section 12, C.

4. Tests in the manufacturer's works

B.5. is applicable as appropriate.

For hydraulic pumps and motors with a drive power of 100 kW or more, the tests are to be conducted in the presence of a GL Surveyor.

For lateral thrust units with an input power of less than 100 kW final inspection and function tests may be carried out by the manufacturer, who will then issue the relevant Manufacturer Inspection Certificate.

5. Shipboard trials

Testing is to be carried out during sea trials during which the operating times are to be established.

D. Podded Drives

1. Definition

The propulsion power for this type of drive will be created by an electric motor in the underwater gondola of the drive and directly transmitted to one or two propellers at the gondola ends. The underwater part of the system is turnable in a similar way as foreseen for rudder propellers and therefore a steering effect with full propulsion power can be achieved.

2. Structural measures

The space where the podded drive is connected to the unit's hull has to be surrounded by longitudinal and transverse watertight bulkheads. The thickness of the shell has to be increased locally.

As podded drives are of novel design direct calculations of the scantlings have to be submitted to GL.

3. Requirements for the components

If the podded drives shall be subject to Classification its components must fulfil the requirements of the already existing GL Rules, such as:

- gears, couplings, see Section 5
- shafting, see A.
- propeller, see A.
- turning mechanism: analogous to rudder propellers, see B.
- electrical installations, see Chapter 6 – Electrical Installations, Section 12, D.

E. Dynamic Positioning Systems (DP Systems)

1. General

1.1 Scope

The complete installation necessary for positioning a unit dynamically comprises the sub-systems:

- power system
- thruster system
- control system
For the electrical equipment see Chapter 6 – Electrical Installations, Section 12, E.

1.2 Position keeping

Position keeping means maintaining a desired position within the normal excursions of the control system and under the defined environmental conditions.

2. Requirements for Class Notations

2.1 Reliability

A DP system consists of components and systems acting together to achieve sufficient reliable position keeping capability. The necessary reliability is determined by the consequence of a loss of position keeping capability. The larger the consequence, the more reliable the DP system shall be.

Consequently the requirements have been grouped into three Class Notations. For each Class Notation the associated single failure criteria shall be defined.

The Class Notation of the unit required for a particular operation is based on a risk analysis of the consequence of a loss of position.

2.2 Class Notations

2.2.1 For Class Notation DP 1, loss of position may occur in the event of a single fault.

2.2.2 For Class Notation DP 2, a loss of position may not occur in the event of a single fault in any active component or system. Static components will not be considered to fail where adequate protection from damage is demonstrated and reliability is to the satisfaction of GL. Single failure criteria apply to:

- any active component or system, e.g. generators, thrusters, switchboards, remote controlled valves, etc.
- any static component, e.g. cables, pipes, manual valves, etc. which is not properly documented with respect to protection and reliability

2.2.3 For Class Notation DP 3, a single failure applies to:

- items listed above for Class Notation DP 2, additionally any normally static component is assumed to fail
- all components in any one watertight compartment, caused by fire or flooding
- all components in any one fire sub-division, caused by fire or flooding

2.2.4 For Class Notations DP 2 and DP 3, a single inadvertent action shall be considered as a single fault, if such an action is reasonably probable.

2.2.5 The requirements for the DP system arrangement for the different Class Notations are shown in Table 6.1.

2.3 Worst case failure

Based on the single failure definitions the worst case failure shall be determined and used as criterion for the consequence analysis.

2.4 Documents for approval

The documents and drawings specified below are to be submitted for approval at least in triplicate. Operation and maintenance manuals may be submitted in a single set:

- general description of the system
- documentation for control, safety and alarm systems including test program
- thruster documentation
- electric power system documentation

2.5 Failure Mode and Effect Analysis (FMEA)/Redundancy test

Documentation concerning reliability and availability of the DP system shall be provided for the Class Notations DP 2 and DP 3 by means of a Failure Mode and Effect Analysis (FMEA). As an alternative to a FMEA the redundancy may be documented in a redundancy test procedure which is to be verified during sea trials.

3. Functional requirements

3.1 All components in a DP system shall be designed, constructed and tested in accordance with GL accepted rules and standards.

3.2 In order to meet the single failure criteria redundancy of components will normally be necessary as follows:

- for Class Notation DP 2, redundancy of all active components
- for Class Notation DP 3, redundancy of all components and physical separation of the components

3.3 For Class Notation DP 3, full redundancy may not always be possible (e.g., there may be a need for a single change-over system from the main computer system to the back-up computer system). Non-redundant connections between usually redundant and separated systems may be accepted, provided that it is shown to give clear safety advantages, and that their reliability can be demonstrated and documented to the satisfaction of GL. Such connections shall be kept to a minimum and made to fail to the safest condition. Failure in one system shall in no case be transferred to the other redundant system.
3.4 Redundant components and systems shall be immediately available and with such capacity that the DP operation can be continued for such a period that the work in progress can be terminated safely. The transfer to the redundant component or system shall be automatic as far as possible, and operator intervention shall be kept to a minimum. The transfer shall be smooth and within acceptable limitations of the operation.

4. Tests

4.1 Factory acceptance test (FAT)

Before a new installation is surveyed and tested factory acceptance tests shall be carried out at the manufacturer’s work. These tests are to be based on the approved program.

4.2 Initial survey

The initial survey shall include a complete survey of the DP system to ensure full compliance with the applicable parts of the Rules:

- verification of redundancy and independence (Class Notations DP 2 and DP 3)
- testing of the alarm system and switching logic of the measuring system (sensor, peripheral equipment and reference system)
- functional tests of control and alarm systems of each thruster
- tests of the electrical installations according to the requirements of Rules
- tests of the remote thrust control
- tests of the complete DP system (all operational modes, back-up system, alarm system and manual override)

The initial survey includes a complete test of all systems and components and of the ability of the unit to keep position after single failures associated with the assigned Class Notation.

5. Further details

### Table 6.1  DP system arrangement

<table>
<thead>
<tr>
<th>Subsystem or component</th>
<th>Minimum requirements for Class Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DP1</td>
</tr>
<tr>
<td><strong>Power System</strong></td>
<td></td>
</tr>
<tr>
<td>Generators and prime mover</td>
<td>non-redundant</td>
</tr>
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<td>Main switchboard</td>
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<tr>
<td>Bus-tie breaker</td>
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<tr>
<td>Distribution system</td>
<td>Non-redundant</td>
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<tr>
<td>Power management</td>
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</tr>
<tr>
<td><strong>Thruster system</strong></td>
<td></td>
</tr>
<tr>
<td>Arrangement of thrusters</td>
<td>non-redundant</td>
</tr>
<tr>
<td><strong>DP-Control system</strong></td>
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</tr>
<tr>
<td>Auto control; no. of computer systems</td>
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</tr>
<tr>
<td>Manual control; joystick with auto heading</td>
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</tr>
<tr>
<td><strong>Sensors</strong></td>
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</tr>
<tr>
<td>Position reference systems</td>
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<td>VRS</td>
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<tr>
<td></td>
<td>Gyro</td>
</tr>
<tr>
<td>Cables and piping system</td>
<td>non-redundant</td>
</tr>
<tr>
<td>Essential non-DP systems</td>
<td>non-redundant</td>
</tr>
</tbody>
</table>
Section 7

Torsional Vibrations

A. General

1. Definitions

1.1 For the purposes of these Rules, torsional vibration stresses are additional loads due to torsional vibrations. They result from the alternating torque which is superimposed on the mean torque.

1.2 The speed range in which the plant can be operated is the service speed range. It covers the range between \( n_{\text{min}} \) (minimum speed) and \( 1.05 \cdot n_{\text{N}} \) (nominal speed).

2. Scope

2.1 For main propulsion plants of mobile offshore units calculation of torsional vibrations is subject to the GL Rules I – Ship Technology, Part 1 - Seagoing Ships, Chapter 2 – Machinery Installations, Section 16.

2.2 For generator sets driven by internal combustion engines with a nominal output of more than 150 kW, calculations of the torsional vibration shall be submitted to GL.

2.3 For other essential auxiliary machinery driven by internal combustion engines with a mechanical output higher than 150 kW, like bow thrusters, etc. or in the case where the power consumption varies periodically causing significant vibratory stresses, like electrically driven piston pumps or similar, torsional vibration calculations shall also be submitted.

B. Extent of Calculations

1. Input for the calculation

The following data shall be included in the analysis:

- equivalent dynamic system comprising individual masses and inertialess torsional elasticities
- relevant data of diesel engine
- relevant data for vibration dampers, if existing
- relevant data for couplings
- relevant data for gears, if applicable
- relevant data for driven unit (pump, generator or similar)

2. Output of the calculation

2.1 Natural frequencies

The natural frequencies of the undamped system and the corresponding vibration modes shall be given.

2.2 Forced vibrations

2.2.1 For systems as mentioned under A.2.2 forced torsional vibration calculations shall be carried out. It shall be shown that the operating speed range is free from harmful torsional vibrations. For generator sets working only at the synchronous speed, only this nominal speed ± 10 % shall be reckoned with. For sets working with varying speed the whole available operating speed range shall be checked. The calculations should indicate the synthesized vibratory torque/stress for the normal and misfiring operation.

2.2.2 For systems as mentioned under A.2.3 forced torsional vibration calculations have only to be carried out in the case that one natural frequency of the system is excited by the frequency of the periodical torque fluctuation within the operational speed range.

C. Permissible Vibratory Loadings

1. Shafting

For shafting, the permissible values as given for intermediate shafting in the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 16 apply in general.

2. Internal combustion engines

For crankshafts of internal combustion engines, the maximum permissible additional shear stress as calculated by means of the GL Rules VI – Additional Rules and Guidelines, Part 4 – Diesel Engines, Chapter 2 - Guidelines for the Calculation of Crankshafts for I.C. Engines may be applied. In general a detailed check will only be necessary for values exceeding ± 30 N/mm².
3. **Gears**

In the service speed range no alternating torque higher than 30 % of the mean torque of the nominal speed should occur in any gear stage. The mean nominal torque is the value of the maximum mean torque transmitted by the gear stage.

For idling gears this maximal value shall not exceed 20 % of the design value of the pinion or wheel under consideration.

4. **Flexible couplings**

For elastic couplings in general, the permissible value given by the coupling manufacturer applies. In special cases, GL may reduce the permissible value given by the coupling manufacturer accordingly. Speed ranges within which, under abnormal operating conditions, continuous operation is not allowed shall be indicated in accordance with D.2.

5. **Generators**

For rigidly coupled generators (without elastic coupling) the vibratory torque in the input part of the generator's shaft shall not exceed 250 % of the nominal torque of the generator set. For the purposes of this Rule nominal torque is the torque which can be calculated by applying the actual data of the internal combustion engine (nominal output / nominal speed).

The mentioned limit of 250 % shall be kept within the speed range 90 % to 105 % of the nominal speed. The calculation for this speed range shall be carried out by using the excitation corresponding to the nominal torque as defined above.

Exceeding the limit of 250 % may be considered in exceptional cases, provided that the generator's manufacturer has designed the generator for a higher dynamical torque. But also in such a case a highest value of 300 % of the actual nominal torque of the set as defined above must not be exceeded.

D. **Prohibited Ranges of Operation**

1. In general, for generators and auxiliary drives as defined for the scope of these Rules, the whole speed range shall be kept free of barred speed ranges.

2. Operating ranges which, because of the magnitude of the torsional vibration stresses, may only be passed through, are to be indicated as prohibited ranges of operation by red marks on the tachometer or in some other suitable manner in all engine control stations.

E. **Torsional Vibration Measurements**

1. For other systems, as described under A.2.2 and A.2.3, measurements will in general not be necessary, provided that the expected (calculated) torsional vibration behaviour fulfils the GL requirements.

2. In special cases of unreliable behaviour of a system, GL may require carrying out of torsional vibration measurements in order to check the calculation results.
Section 8

Windlasses, Winches and Hydraulic Systems

A. Windlasses

1. General

1.1 Scope

1.1.1 Temporary mooring equipment

The following requirements apply to anchor windlasses, rope anchor winches, combined anchor and mooring winches and chain stoppers of the temporary mooring equipment described in Chapter 2, Section 8, B. For anchors and chain cables, see Chapter 2, Section 8, B.3. and B.4.

1.1.2 Positional mooring equipment

Where the positional mooring equipment as described in Chapter 2, Section 8, C. is intended to be installed, the requirements defined in C. have to be considered.

1.2 Documents for approval

1.2.1 For each type of anchor windlass and chain stopper, general and sectional drawings, circuit diagrams of the hydraulic and electrical systems and detail drawings of the main shaft, cable lifter, drum, brake, stopper bar and chain pulley and axle are to be submitted in triplicate for approval.

One copy of a description of the anchor windlass including the proposed overload protection and other safety devices is likewise to be submitted.

1.2.2 Where an anchor windlass is to be approved for several strengths and types of chain cable, the calculation relating to the maximum braking torque is to be submitted and proof furnished of the power and hauling-in speed in accordance with 4.1, corresponding to all relevant types of anchor and chain cable.

1.2.3 One copy of the strength calculation for bolts, chocks and stoppers securing the windlass to the deck is likewise to be submitted. The calculation shall consider forces on the windlass caused by the loads specified in 4.2.

2. Materials

2.1 Approved materials

2.1.1 The provisions contained in Section 6, B.2.1 are to be applied as appropriate to the choice of materials.

2.1.2 Cable lifters and chain pulleys are to be made of steel or cast steel.

2.2 Testing of materials

2.2.1 The materials for forged, rolled and cast parts which are stressed by the pull of the chain when the cable lifter is disengaged (main shaft, cable lifter, drum, brake bands, brake spindles, brake bolts, tension straps, stopper bar, chain pulley and axle) are to be tested under supervision of GL in accordance with the GL Rules II – Materials and Welding, Part 1 – Metallic Materials.

2.2.2 In the case of hydraulic systems, the material used for pipes and pressure vessels is also to be tested, see Section 13d, C.

3. Design of equipment

3.1 Type of drive

3.1.1 Windlasses are normally to be driven by an engine which is independent of other deck machinery. The piping systems of hydraulically driven windlass prime movers may be connected to other hydraulic systems provided that this is permissible for the latter. The windlasses shall, however, be capable of being operated independently of other connected systems.

3.1.2 For hydraulic drives with a piping system connected to other hydraulic systems it is recommended that a stand-by pump unit be fitted.

3.1.3 In the case of windlasses with two cable lifters, both cable lifters have to be engageable simultaneously.

3.2 Reversing mechanism

Power-driven windlasses shall be reversible.

3.3 Overload protection

For the protection of the mechanical parts in the event of the windlass jamming, an overload protection, e.g. slip coupling, relief valve, is to be fitted to limit the maximum torque of the drive engine (cf. 4.1.2). The setting of the overload protection is to be specified, e.g. in the operating instructions.

3.4 Couplings

Windlasses are to be fitted with disengageable couplings between the cable lifter and the drive shaft. In
an emergency, hydraulically or electrically operated couplings shall be capable of being disengaged by hand.

3.5 Braking equipment

Windlasses shall be fitted with cable lifter brakes which are capable of holding a load in accordance with 4.2.3 with the cable lifter disengaged. In addition, where the gear mechanism is not of self-locking type, a device, e.g. gearing brake, lowering brake, oil hydraulic brake, is to be fitted to prevent paying out the chain should the power unit fail while the cable lifter is engaged.

3.6 Pipes

For the design and dimensioning of pipes, valves, fittings, pressure vessels, etc. Section 12c (Pressure Vessels, Heat Exchangers and Filters) and Section 13d (General Design of Piping Systems), D. are to be applied, as appropriate, to hydraulic piping systems.

3.7 Cable lifters

Cable lifters shall have at least five snugs.

3.8 Windlass as warping winch

Combined windlasses and warping or mooring winches may not be subjected to excessive loads even when the maximum pull is exerted on the warping rope.

3.9 Electrical equipment

The electrical equipment is to comply with Chapter 6 - Electrical Installations.

3.10 Hydraulic equipment

Tanks forming part of the hydraulic system are to be fitted with oil level indicators. For filters see D.1.3.3.

4. Power and design

4.1 Driving power

4.1.1 Depending on the grade of the chain cable, windlasses shall be capable of exerting the following nominal pull \( Z' \) at a mean speed of at least 0,15 m/s:

\[
Z' = 37.5 \cdot d^2 \quad [N] \quad \text{for grade K1}\n\]

\[
Z' = 42.5 \cdot d^2 \quad [N] \quad \text{for grade K2}\n\]

\[
Z' = 47.5 \cdot d^2 \quad [N] \quad \text{for grade K3}\n\]

\( d = \) diameter of anchor chain [mm]

For anchor depths of more than 100 m the windlass shall be able of exerting a nominal pull \( Z \) of

\[
Z = Z' + 0.218 \cdot d^2 \cdot (h - 100) \quad [N]
\]

\( h = \) anchor depth [m]

4.1.2 The nominal output of the power units shall be such that the conditions specified in 4.1.1 can be met during the hauling-in period without interruption. In addition, the power units shall be capable of developing a maximum torque corresponding to a maximum pull \( Z_{\text{max}} \) of

\[
Z_{\text{max}} = 1.5 \cdot Z' \quad [N] \quad \text{for anchor depth} \leq 100 \text{ m}\n\]

\[
Z_{\text{max}} = 1.5 \cdot Z \quad [N] \quad \text{for anchor depth} > 100 \text{ m}\n\]

at a correspondingly reduced lifting speed for at least two minutes.

4.1.3 The maximum torque specified in 4.1.2 need not be exerted if the anchor will be broken out of the ground and put to a new position by an anchor handling vessel.

4.1.4 An additional reduction gear stage may be fitted in order to achieve the maximum torque.

4.2 Design of load transmitting components and chain stoppers

4.2.1 The basis for the design of the load-transmitting components of windlasses and chain stoppers are the anchors and chain cables specified in Chapter 2, Section 8, B.

4.2.2 The cable lifter brake is to be so designed that the anchor and chain cable can be safely stopped while paying out the warping rope.

4.2.3 The dimensional design of those parts of the windlass which are subjected to the chain pull when the cable lifter is disengaged (cable lifter, main shaft, braking equipment, bedframe and deck fastening) is to be based on a theoretical pull equal to 80 % of the nominal breaking load specified in the GL Rules II - Materials and Welding, Part 1 – Metallic Materials, Chapter 4 - Equipment, Section 2 for the chain cable in question, where chain cables are led through hawse pipes, or 100 % where no hawse pipes are fitted and the chain cables are guided by fairleads and sheaves. The design of the main shaft is to take account of the braking forces and the cable lifter brake shall not slip when subjected to this load.

For windlasses with ropes and drums the dimensional design of the parts which are subjected to rope pull when the drum is disengaged (drum, main shaft, braking equipment, bedframe and deck fastening) is to be based on 100 % of the nominal breaking load of the rope where ropes are guided by fairleads and sheaves. The design of the main shaft is to take account of the braking forces and the drum brake shall not slip when subjected to this load.

1 Grade K1 not recommended for offshore use.
4.2.4 The theoretical pull may be reduced to 45 % or 50 % of the nominal breaking load of the chain cable for hawse pipes or fairleads respectively, provided that a chain stopper approved by GL is also fitted.

4.2.5 The design of all other windlass components is to be based on a force acting on the cable lifter pitch circle that is equal to 1,5 times the nominal pull \( Z \) specified in 4.1.1.

4.2.6 At the theoretical pull specified in 4.2.3 and 4.2.4, the force exerted on the brake hand wheel shall not exceed 500 N.

4.2.7 The dimensional design of chain stoppers is to be based on a theoretical pull as specified in 4.2.3.

4.2.8 The total stresses applied to components shall be below the minimum yield strength of the materials used.

4.2.9 The design of foundations and pedestals of windlasses and chain stoppers shall correspond to the principles for structural design defined in Chapter 4, Sections 3 and 4.

4.2.10 For units of a length of 80 m or more, where the height of the exposed deck in way of windlasses is less than 0,1 length or 22 m above the summer load waterline, whichever is the lesser, the attachment of the windlass within the forward quarter length of the unit are to resist green sea forces. Where mooring winches are integrated with the anchor windlass, they are to be considered as part of the windlass. The attachment has to be calculated according to GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 14, D.4.3.

5. Tests in the manufacturer's works

5.1 Testing of driving engines

The power units are required to undergo tests on a test stand in the manufacturer's works.

5.1.1 For diesel engines, see Section 3.

5.1.2 For electric motors, see Chapter 6 – Electrical Installations, Section 15.

5.1.3 For hydraulic pumps and motors the GL Rules VI – Additional Rules and Guidelines, Part 6 – Pumps – Compressors – Fittings, Chapter 1 – Guidelines for the Design, Construction and Testing of Pumps are to be applied analogously. Where the drive power is 50 kW or more the testing is to be carried out in the presence of a GL Surveyor.

5.2 Pressure and tightness tests

Pressure components are to undergo a pressure test. The test pressure is \( p_C \):

\[
p_C = 1.5 \cdot p
\]

\( p \) = the maximum allowable working pressure [bar] = the pressure at which the relief valves open. However, for working pressures above 200 bar the test pressure need not exceed \( p + 100 \) bar.

For pressure testing of pipes, their valves and fittings, see Section 13d.

Tightness tests are to be performed on components to which this is appropriate.

5.3 Final inspection and operational testing

5.3.1 Following manufacture, windlasses are required to undergo final inspection and operational testing at 1,5 times the nominal pull. The hauling-in speed is to be verified with continuous application of the nominal pull. During the tests, particular attention is to be given to the testing and, where necessary, the setting of braking and safety equipment.

In the case of anchor windlasses for chains greater 14 mm in diameter these tests are to be performed in the presence of the GL Surveyor.

5.3.2 Where the manufacturer does not have adequate facilities, the aforementioned tests, including the adjustment of the overload protection, can be carried out on board. In these cases, functional testing in the manufacturer’s works is to be performed under no-load conditions.

5.3.3 Following manufacture, chain stoppers are required to undergo final inspection and operational testing in presence of the GL Surveyor.

6. Sea trials

The anchor equipment is to be tested during sea trials. As a minimum requirement, this test is intended to demonstrate that the conditions specified in 3.1.3 and 4.2.2 can be fulfilled.

B. Winches

1. Towing winches

The design and testing of towing winches are to comply with the most recent edition of the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 1 – Hull Structures, Section 25, C.

2. Winches for cargo handling gear and other lifting equipment

The design and testing of these winches are to comply with the most recent edition of the GL Rules VI –

3. Lifeboat winches

The design and testing of lifeboat winches are to comply with the most recent edition of the GL Rules VI – Additional Rules and Guidelines, Part 2 – Lifting Appliances, Lifting Appliances, Accesses, Chapter 1 – Guidelines for Life Saving Launches Appliances.

4. Winches for special equipment

The GL Rules VI – Additional Rules and Guidelines, Part 2 – Life-Saving Appliances, Lifting Appliances, Accesses, Chapter 2 - Guidelines for the Construction and Survey of Lifting Appliances are to be applied, as appropriate, to winches for special equipment such as ramps, hoisting gear and hatch covers.

C. Winches for Positional Mooring

In addition to the requirements defined in A., the following requirements have to be observed.

1. General

1.1 Scope

1.1.1 Reference is made to the Positional mooring system defined in Chapter 2, Section 8, C.

1.1.2 General requirements for mooring winches are also dealt with in ISO Standard 3730 and 7825.

1.2 Documents for approval

1.2.1 For each type of mooring winch general and sectional drawings, circuit diagrams of the hydraulic and electrical systems and detail drawings of the frame, main shaft, drum and brake are to be submitted in triplicate for approval.

1.2.2 One copy of the description of the mooring winch including the safety devices is to be submitted.

1.2.3 One copy of the strength calculation for bolts, chocks and stoppers securing the mooring winch to the deck are to be submitted.

1.2.4 If several mooring winches have to work together as a positional mooring system, an operating and maintenance manual including the interaction in the system is to be submitted.

2. Materials

2.1 Approved materials

2.1.1 The provisions contained in Section 6, B.2.1 are to be applied as appropriate to the choice of materials.

2.2 Testing of materials

2.2.1 The materials for forged, rolled and cast parts which are stressed by the pull of the mooring rope (main shaft, drum, brake bands, brake spindles, brake bolts, tension straps) are to be tested under supervision of GL in accordance with the GL Rules II – Materials and Welding, Part 1 – Metallic Materials.

2.2.2 In case of hydraulic systems, the materials used for pipes and pressure vessels are also to be tested, see Section 13d, C.

2.3 Certificates

2.3.1 GL Material Certificates according to The GL Rules II – Materials and Welding, Part 1 – Metallic Materials, Chapter 1 – Principles and Test Procedures, Section 1, H. will generally be required for:

- frame, drum, shaft(s), couplings, brakes, gear(s)
- mooring rope(s), including Certification of breaking load

2.3.2 Manufacturer Inspection Certificates according to the GL Rules defined in 2.3.1 may be accepted for standard items, if the manufacturer is recognized by GL.

3. Design of equipment

3.1 Type of drive

3.1.1 The drive of the winch shall be hydraulic or electric, a drive using steam would only be recommendable if the main propulsion system uses steam.

3.2 Winch drums

3.2.1 If constant brake holding capacity and heaving forces are to be maintained, split drums with a tension section and a storage section should be provided. The tension section shall be wide enough for ten turns of mooring line to reach a very low load at the transfer point to the storage drum.

3.2.2 To ensure security of the rope end fastening at least 3 dead turns shall remain on the drum.

3.2.3 If an undivided drum is used, special attention is to be given to properly spooling of the mooring line to avoid line damage. If no special spooling device is provided the winch should be placed symmetrically and with a sufficient distance to the fairlead.
3.2.4 If a multi-drum winch is used, each winch drum shall be capable of independent operation.

3.2.5 The drum diameter shall be at least 16 times the wire rope diameter. The drum capacity shall be capable of storing the total length of the mooring line. For synthetic ropes the drum diameter shall be chosen according to ISO 3730.

3.2.6 If band brakes are used at the drum, mooring lines shall be spooled onto the drum on the correct direction, since band brakes are designed to work in one direction only.

3.3 Braking equipment

3.3.1 Each mooring winch is to be provided with two independent power operated brakes, and each brake is to be capable of holding against a static load in the mooring line of at least 50 % of its breaking strength. Where agreed by GL, one of the brakes may be replaced by a manually operated brake.

3.3.2 On loss of power to the winch, the alternative power operated braking system shall be automatically applied and be capable of holding against 50 % of the anchor line breaking strength.

Winch brakes shall be of the fail safe spring applied type.

3.3.3 It is recommended to use disc brakes also for drum brakes instead of band brakes because disc brakes are less sensitive to friction changes.

3.3.4 Multiple drum winches require a brake for each drum.

3.3.5 Special attention shall be given to the strength of the connection of the brake band to the unit’s structure.

3.3.6 Regardless of the brake type periodic brake testing is essential to assure a safe mooring. Testing provisions should be already incorporated in the winch design. A test program is to be submitted to GL.

3.4 Winch control

3.4.1 A manned central control station shall be provided for the operation of the complete positional mooring system. Each winch shall be equipped with devices for measuring the mooring forces and the speed of the mooring rope. These values shall be monitored also at the central control station together with the wind speed and direction.

3.4.2 Each windlass shall be capable of being controlled from a position which provides a good view of the operation. Means are to be provided at the local windlass control position to monitor anchor line tension, speed and windlass power load and to indicate the amount of anchor line paid out.

3.4.3 Automatic tension mooring winches should only be used in the manual mode of operation. Otherwise the mooring position could be changed by automatically heave-in whenever the line tension falls on one line and pay out of the opposite line when the tension exceeds a pre-set value.

3.4.4 Reliable means are to be provided to communicate between all locations critical to the positional mooring operations.

4. Power and design

4.1 Power and speed to be provided as well as design characteristics have to be agreed with GL.

4.2 The design of the mooring winch is to provide for adequate dynamic breaking capacity to control normal combinations of loads from the anchor, anchor chain cable, mooring line and anchor handling vessel during deployment of the anchors at maximum design payout speed of the winch.

4.3 Winches shall be clearly marked with the breaking strength of the mooring line for which they are designed.


4.5 The attachment of the mooring winch to the hull structure is to be designed to withstand a force corresponding to the breaking strength of the mooring line as specified in Chapter 2, Section 8, B.1.5.

5. Tests in the manufacturer’s works

5.1 Testing of power units

The winch power unit has to be subjected to a test bed trial at the manufacturer’s works with its rated performance. A Manufacturer Test Certificate according to the GL Rules defined in 2.3.1 has to be presented on the occasion of the final inspection of the winch.

5.2 Pressure and tightness testing

A.5.2 is applicable in analogous manner.

5.3 Final inspection and operational testing

5.3.1 Upon completion, winches have to be subjected to a final inspection and an operational test to the rated load. The hauling speed has to be determined during an endurance test under the rated tractive force. During these trials, in particular the braking and safety equipment shall be tested and adjusted.
The brake has to be tested to a test load equal to the rated holding capacity.

5.3.2 If manufacturers do not have at their disposal the equipment required, a test confirming the design winch capacity, and including adjustment of the overload protection device, may be carried out after installation on board, see 6.

In that case only the operational trials without applying the prescribed loads will be carried out at the manufacturers.

6. Sea trials

6.1 If the mooring winch could not be tested at the manufacturer’s works with the rated performance, these tests shall be done during sea trials.

6.2 The interaction of the different mooring winches has to be tested in a realistic way as much similar as possible to the operation in service.

D. Hydraulic Systems

1. General

1.1 Scope

The following requirements apply to hydraulic systems used, for example, to operate hatch covers, closing appliances in the shell and bulkheads, hoists and jacking systems. The Rules are to be applied in analogous manner to other hydraulic systems.

1.2 Documents for approval

The diagram of the hydraulic system together with drawings of the cylinders, containing all the data necessary for assessing the system, e.g. operating data, descriptions, materials used, etc. are to be submitted in triplicate for approval.

1.3 General design criteria

1.3.1 For the design of pressure vessels, see Section 12c; for the dimensions of pipes, see Section 13b.

1.3.2 Pipes

1.3.2.1 Pipes shall be installed and secured in such a way as to protect them from damage while enabling them to be properly maintained from outside.

1.3.2.2 Pipes may be led through tanks in pipe tunnels only. The laying of such pipes through operating spaces shall be restricted to the essential minimum. The piping system shall be fitted with relief valves to limit the pressure to the maximum allowable working pressure.

1.3.3 Filters

The piping system shall be fitted with filters for cleaning the hydraulic fluid.

Equipment shall be provided to enable the hydraulic system to be vented.

1.3.4 Accumulators

The accumulator space of the hydraulic accumulator shall allow permanent access to the relief valve of the connected system. The gas chamber of the accumulator may be filled only with inert gases. Gas and operating medium shall be separated by accumulator bags, diaphragms or similar.

1.3.5 Oil level indicators

1.3.5.1 Tanks forming part of the hydraulic system shall be fitted with oil level indicators.

1.3.5.2 The lowest permissible oil level shall be monitored by the general machinery alarm system.

1.3.6 Pressure relieve valves

To avoid excessive overpressure safety valves have to be provided. Safety valves shall be capable of discharging the medium at a maximum pressure increase of 10 % of the allowable working pressure. Safety valves are to be fitted at the low pressure side of reducing valves.

1.4 Hose assemblies and compensators

The requirements for hose assemblies and compensators according to Section 13d, E.3. apply.

2. Materials

2.1 Approved materials

2.1.1 Components fulfilling a major function in the power transmission system shall normally be made of steel or cast steel in accordance to the GL Rules II – Materials and Welding. The use of other materials is subject to special agreement with GL.

Cylinders are preferably to be made of steel, cast steel or nodular cast iron with a predominantly ferritic matrix.

Hoisting cylinders for jacking systems shall be made of steel or cast steel in accordance with Chapter 4 – Structural Design, Section 4.

2.1.2 Pipes are to be made of seamless or longitudinally welded steel tubes.

2.1.3 The pressure-loaded walls of valves, fittings, pumps, motors, etc. are subject to the requirements of Section 13b.
2.2 Testing of materials

The following components are to be tested in accordance with the GL Rules II – Materials and Welding, Part I – Metallic Materials in presence of a GL Surveyor:

a) Pressure pipes with nominal diameter \( D_N > 32 \), see Section 13d, Table 13d.3

b) Cylinder tubes, where the product of the pressure times the diameter:

\[
p \cdot D_i > 20000
\]

\( p \) = maximum allowable working pressure or set pressure of the relief valve respectively [bar]

\( D_i \) = inside diameter of tube [mm]

c) For testing of materials for hydraulic accumulators, see Section 12c.

Testing of materials by GL may be dispensed with in the case of cylinders for secondary applications, provided that evidence in the form of a Manufacturer Test Report in accordance with GL Rules II – Materials and Welding, Part I – Metallic Materials, Chapter 1 – Principles and Test Procedures, Section 1, H. is supplied.

3. Hydraulically operated closing appliances in the shell of mobile offshore units

3.1 Scope

The following requirements apply to the power equipment of hydraulically operated door closing appliances in the unit’s shell which are not normally operated while at sea. For the design and arrangement of the closures, see GL Rules I – Ship Technology, Part I - Seagoing Ships, Chapter 1 – Hull Structures, Section 6.

3.2 Design and construction

3.2.1 The movement of shell doors, etc. may not be initiated merely by the starting of the pumps at the power station.

3.2.2 Local control, inaccessible to unauthorized persons, is to be provided for every closing appliance in the unit’s shell. As soon as the controls (pushbuttons, levers or similar) are released, movement of the appliance shall stop immediately.

3.2.3 Closing appliances in the unit’s shell have normally to be visible from the control stations. If the movement cannot be observed, audible alarms are to be fitted. In addition, the control stations are then to be equipped with indicators enabling the execution of the movement to be monitored.

3.2.4 Closing appliances in the unit’s shell are to be fitted with devices which prevent them from mov-}

ing into their end positions at excessive speed. Such devices are not to cause the power unit to be switched off.

As far as is necessary, mechanical means shall be provided for locking closing appliances in the open position.

3.2.5 Every power unit driving horizontally hinged or vertically operated closing appliances is to be fitted with throttle valves or similar devices to prevent sudden dropping of the closing appliance.

3.2.6 It is recommended that the driving power be shared between at least two mutually independent pump units.

3.3 Pipes, hose assemblies

3.3.1 Connection between the hydraulic system used for operation of the closing appliances and other hydraulic systems is permitted only with the consent of GL.

3.3.2 For oil level indicators, see 1.3.5.

3.3.3 The construction of hose assemblies shall conform to Section 13d, E.3. The requirement that hose assemblies shall be of flame-resistant construction may be set aside for hose lines in spaces not subject to fire hazard and in systems not important to the safety of the unit.

3.3.4 The materials used for pressurized components including the seals shall be suitable for the hydraulic oil in use.

4. Hydraulic operating systems for watertight doors

4.1 General, application

4.1.1 The following requirements apply to the power equipment of hydraulically operated watertight doors.

4.1.2 For the number, design and arrangement of bulkhead doors, the GL Rules I – Ship Technology, Part I - Seagoing Ships, Chapter 1 – Hull Structures, Section 6 may be applied.

The requirements of Chapter II-1, Regulation 13, of SOLAS 74 are not affected by these provisions.

4.2 Design requirements

4.2.1 Watertight doors shall be power-driven sliding doors moving horizontally. Other designs require the approval of GL and the provision of additional safety measures where necessary.

4.2.2 Wherever applicable, the pipes of hydraulic watertight door closing systems are governed by the
Rules in 3.2, with the restriction that the use of flexi-
ble hoses is not permitted.

4.2.3 The hydraulic system for watertight doors
shall not be connected to other hydraulic systems.

4.2.4 A selector switch with the switch positions
"local control" and "close all doors" is to be provided
at the central control station. Under normal conditions
this switch should be set to "local control".

In the "local control" position, the doors may be lo-
cally opened and closed without automatic closure.

In the "close doors" position, all doors are closed
automatically. They may be reopened by means of the
local control device but shall close again automatically
as soon as the local door controls are released.

It shall not be possible to open the closed doors from
the bridge or central control station.

4.2.5 Closed or open watertight doors shall not be
set in motion automatically in the event of a power
failure.

4.2.6 The control system is to be designed in such a
way that an individual fault inside the control system,
including the piping, does not have any adverse effect
on the operation of other watertight doors.

4.2.7 The controls for the power drive are to be
located at least 1,6 m above the floor on both sides of
the bulkhead close to the door. The controls are to be
installed in such a way that a person passing through
the door is able to hold both controls in the open posi-
tion.

The controls shall return to their original position
automatically when released.

4.2.8 The direction of movement of the controls is
to be clearly marked and shall be the same as the di-
rection of movement of the door.

4.2.9 In the event that an individual element fails
inside the control system for the power drive, includ-
ing the piping, but excluding the closing cylinders on
the door or similar components, the operational ability
of the manually operated control system shall not be
impaired.

4.2.10 The movement of the power driven water-
tight doors may not be initiated simply by switching
on the drive units, but only by actuating additional
devices.

4.2.11 The control and monitoring equipment for the
drive units is to be housed in the central control station
on the bridge.

4.2.12 Manual control

Each door shall have a manual control system which is
independent of the power drive.

4.2.13 Indicators

Visual indicators to show whether each watertight
door is fully open or closed are to be installed at the
central control station on the bridge.

4.2.14 Electrical equipment

For details of electrical equipment, see Chapter 6.

4.3 Additional requirements for hydraulic
power systems

The following requirements have to be applied to units
considered as "special purpose ships" carrying more
than 200 special personnel on board in accordance
with IMO Resolution A.534(13) adopted on 17 No-
vember 1983 – Code of Safety for Special Purpose
Ships.

4.3.1 Watertight doors together with the power
plants and including the piping, electric cables and
control instruments are to be arranged inboard of the
zone of assumed damaged penetration, unless spe-
cially considered in the damage stability calculations,
and generally not less than 1,5 m from the unit’s outer
shell.

4.3.2 Watertight doors shall be capable of being
closed securely using the power drive as well as using
the manual control even when the unit has a perma-
nent heel of 15°.

4.3.3 The force required to close a door is to be
calculated based on a static water pressure of at least 1
m above the door coaming.

4.3.4 All power driven doors must be capable of
being closed simultaneously from the bridge or central
control station, with the unit upright, in no more than
60 seconds.

4.3.5 The closing speed of each individual door
must have a uniform rate. The closing time with
power operation and with the unit upright may be no
more than 40 seconds and no less than 20 seconds
from the start of the motion with the door completely
open until it is closed.

4.3.6 Power operated watertight door closing sys-
tems may be fitted as an option with a central hydrau-
lic drive for all doors or with mutually independent
hydraulic or electric drives for each individual door.

4.3.7 Central hydraulic system - power drives

4.3.7.1 Two mutually independent power pump units
are to be installed, if possible above the bulkhead or
freeboard deck and outside the machinery spaces.

4.3.7.2 Each pump unit must be capable of closing
all connected watertight doors simultaneously.

4.3.7.3 The hydraulic system must incorporate ac-
cumulators with sufficient capacity to operate all con-

nected doors three times, i.e. close, open and reclose, at the minimum permitted accumulator pressure.

4.3.8 Individual hydraulic drive

4.3.8.1 An independent power pump unit is to be fitted to each door for opening and closing the door.

4.3.8.2 An accumulator must also be provided with sufficient capacity to operate the door three times, i.e. close, open and reclose, at the minimum permitted accumulator pressure.

4.3.9 Individual electric drive

4.3.9.1 An independent electric drive unit is to be fitted to each door for opening and closing the door.

4.3.9.2 In the event of a failure of either the main power supply or the emergency power supply, the drive unit must still be capable of operating the door three times, i.e. close, open and re-close.

4.3.10 Manual control

4.3.10.1 Manual controls must be capable of being operated at the door from both sides of the bulkhead as well as from an easily accessible control station located above the bulkhead or freeboard deck and outside the machinery space.

4.3.10.2 The control at the door must allow the door to be opened and closed.

4.3.10.3 The control above the deck must allow the door to be closed.

4.3.10.4 The fully open door must be capable of being closed using manual control within 90 seconds with the unit upright.

4.3.10.5 A means of communication is to be provided between the control stations for remote manual drive above the bulkhead or freeboard deck and the central control station.

4.3.11 Indicators

The indicators described in 4.2.13 are to be installed at the operating stations for manual control above the bulkhead or freeboard deck for each door.

4.3.12 Alarms

4.3.12.1 While all the doors are being closed from the central control station, an audible alarm must sound at each door. This alarm must start at least 5 seconds - but not more than 10 seconds - before the door starts moving and must continue throughout the door movement.

4.3.12.2 When the door is being closed by remote control using the manual control above the bulkhead or freeboard deck, it is sufficient for the alarm to sound only while the door is actually moving.

4.3.12.3 The installation of an additional, intermittent visual alarm may be required in the accommodation areas and in areas where there is a high level of background noise.

4.3.12.4 With a central hydraulic system, the minimum permitted oil level in the service tank is to be signalled by means of an independent audible and visual alarm at the central control station.

4.3.12.5 The alarm described in 4.3.12.4 is also to be provided to signal the minimum permitted accumulator pressure of the central hydraulic system.

4.3.12.6 In a decentralized hydraulic system which has individual drive units on each door, the minimum permitted accumulator pressure is to be signalled by means of a group alarm at the central control station on the bridge.

Visual indicators are also to be fitted at the operating stations for each individual door.

5. Hoists

5.1 Definition

For the purposes of these Rules, hoists include hydraulically operated appliances such as lifts and similar equipment.

5.2 Design and construction

5.2.1 The power supply for hoists may be supplied either by a combined power station or individually by several power stations.

In the case of a combined power supply and hydraulic drives whose piping systems are connected to other hydraulic systems, a second pump unit shall be fitted.

5.2.2 The movement of hoists shall not be capable of being initiated merely by starting the pumps. The movement of hoists is to be controlled from special operating stations. The controls shall be so arranged that, as soon as they are released, the movement of the hoist ceases immediately.

5.2.3 Local controls, inaccessible to unauthorized persons, are to be fitted. The movement of hoists should normally be visible from the operating stations. If the movement cannot be observed, audible and/or visual warning devices are to be fitted. In addition, the operating stations are then to be equipped with indicators for monitoring the movement of the hoist.

5.2.4 Devices are to be fitted which prevent the hoist from reaching its end position at excessive speed. These devices are not to cause the power unit to be switched off. As far as is necessary, mechanical means must be provided for locking the hoist in its end positions.
If the locking devices cannot be observed from the operating station, a visual indicator is to be installed at the operating station to show the locking status.

5.2.5 If the power unit fails or a pipe ruptures, shall be ensured that the hoist is slowly lowered.

5.3 Pipes, hose assemblies
1.3.2.1, 1.3.2.2 and 1.4.3. apply in analogous manner to the pipes and hose lines of hydraulically operated hoists.

6. Hydraulic jacking systems

6.1 General, application

6.1.1 The following requirements apply to the power equipment of hydraulically operated jacking systems.

6.1.2 For the general requirements and layout of jacking systems, see Section 9.

6.1.3 The maximum working pressure for the hydraulic system has to be determined based on the design loads as defined in Section 9, C.

6.2 Design requirements for the jacking system

6.2.1 Relief valves have to be provided for protecting any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source.

The relief valves shall be set to a pressure value equal or higher than the maximum working pressure but lower than the design pressure.

The minimum discharge capacity of the relief valve(s) should not be less than 1,1 times the total capacity of the pumps, which can deliver through it (them).

6.2.2 The hydraulic system has to be equipped with blocking valves to keep the different jacking positions.

6.2.3 Hydraulic jacking systems may be served either by one common power station for all legs or by several power stations individually assigned to each leg.

Where a common power station is used, at least two pump units are to be fitted.

Where the systems are supplied individually, changeover valves or fittings are required so that operation can be maintained should one pump unit fail.

6.2.4 The design pressure for calculation to determine the scantlings of piping and other components of the jacking system subjected to internal hydraulic pressure shall be at least the maximum working pressure as defined above and has not to be less than the setting of the relief valves as described under 6.2.1.

6.2.5 The minimum design temperature for the hydraulic jacking system is generally the minimum design temperature as defined for the offshore unit.

It has to be ensured that the hydraulic system is operable at this minimum design temperature.

Where the hydraulic jacking system is protected by an appropriate shelter (e.g. installed inside an enclosed jack house) or equipped with a heating device, a higher minimum design temperature for the jacking system may be accepted.

The minimum design temperature for the hydraulic jacking system is also relevant for the material selection for the components of the jacking system.

6.3 Design requirements for the main hoisting cylinders (Jacks)

6.3.1 With respect to the material selection the main hoisting cylinder is generally classed as primary structural member (compare Chapter 4 – Structural Design, Section 4, A.2.). Parts of the cylinder which are loaded multi-axial (bottom with pad-eye) are classed as special members. For the material selection the minimum design temperature of the jacking system has to be considered, see 6.2.5.

6.3.2 For all load bearing parts of the cylinder a GL Material Certificate (3.2 ISO 10204 : 1995) is generally required.

6.3.3 The parts of the cylinder subject to internal pressure are to be designed according to Section 12c, D.

The strength of other parts of the cylinder has to be verified using the safety factors as laid down in Chapter 4 – Structural Design, Section 3, D.2. for loading condition 2.

Safety against buckling of the cylinder has to be verified for the maximum pushing force. The safety factor against buckling shall not be less than 2,0.

6.4 Other hydraulic cylinders in the jacking system

6.4.1 With respect to material selection other cylinders are generally classed as primary members.

6.4.2 A 3.1 material Certificate is generally required for all parts of the cylinders.

6.4.3 The parts of the cylinders subject to internal pressure are to be designed according to Section 12c, D.

7. Tests in the manufacturer's works

7.1 Testing of power units

The power units are required to undergo testing on a test bed. Factory test certificates for this testing are to
be presented at the final inspection of the hydraulic system.

7.2 Pressure and tightness tests
A.5.2 is applicable in analogous manner.

8. Shipboard trials
After installation, the equipment is to undergo an operational test.

The operational test of watertight doors is to include the emergency operating system and the determination of the closing times.

For trials of jacking systems see also Section 9, E.

E. Fire Door Control Systems
The following requirements have to be applied to units considered as "special purpose ships" carrying more than 200 special personnel on board in accordance with IMO Resolution A.534(13) adopted on 17 November 1983 – Code of Safety for Special Purpose Ships.

1. General

1.1 Scope
The following requirements apply to power operated fire door control systems. (These requirements are in line with the requirements for the control systems of fire doors laid down in Chapter II-2, Rule 30 of the International Convention for the Safety of Life at Sea, 1974). The following requirements may be applied as appropriate to other fire door control systems.

1.2 Documents for approval
The electric and pneumatic diagram together with drawings of the cylinders containing all the data necessary for assessing the system, e.g. operating data, descriptions, materials used etc., are to be submitted in triplicate for approval.

1.3 Dimensional design
For the design of pressure vessels, see Section 12c; for the dimensions of pipes, see Section 13d.

2. Materials

2.1 Approved materials
Cylinders are preferably to be made of stainless steel.

Stainless steel is to be used for pipes in the area of the door. Only corrosion-resistant materials are to be used for the other pipes.

The use of other materials is subject to special agreement by GL.

The use of hose lines is not permitted.

Insulation material has to be of an approved type.

The quality properties of all critical components for operation and safety must conform to recognized rules and standards.

2.2 Testing of materials
Suitable proof of the quality properties of the material used is to be furnished. This proof may take the form of a GL material test Certificate or a material Certificate issued by the producer.

The GL Surveyor reserves the right to order supplementary tests of his own to be carried out where he considers that circumstances justify this.

See Section 12c for details on the material testing of compressed air accumulators.

3. Design

3.1 Each door must be capable of being opened and closed by a single person from both sides of the bulkhead.

3.2 Fire doors must be capable of closing automatically against a permanent heeling angle of the unit of 3.5 °.

3.3 The closing time of hinged doors, with the unit upright, may be no more than 40 seconds and no less than 10 seconds from the start of the movement of the door when fully open to its closed position for each individual door.

The closing speed of sliding doors must be steady and, with the unit upright, may be no more than 0.2 m/s and no less than 0.1 m/s.

Measures must be taken to ensure that any persons in the door areas are protected from excessive danger.

3.4 All doors must be capable of being closed from the central control station either jointly or in groups. It must also be possible to initiate closure at each individual door. The closing switch is to take the form of a locking switch.

3.5 Visual indicators are to be installed at the central control station to show that all fire doors are fully closed.

3.6 Controls for the control system are to be installed next to each door on both sides of the bulkhead and by their operation a door which has been closed from the central control station can be reopened. The controls must return to their original position when released, thereby causing the door to close again.
In an emergency it must be possible to use the controls to interrupt immediately the opening of the door and bring about its immediate closure.

A combination of the controls with the door handle may be permitted.

The controls are to be designed in such a way that an open door can be closed locally. In addition, each door must be capable of being locked locally in such a way that it can no longer be opened by remote control.

3.7 The control unit at the door is to be equipped with a device which will vent the pneumatic system or cut off the electric energy of the door control system, simultaneously shutting off the main supply line, thereby allowing emergency operation by hand.

3.8 The door shall close automatically should the central power supply fail. The doors may not reopen automatically when the central supply is restored.

Accumulators are to be positioned in the immediate vicinity of the door, being sufficient to allow it to be completely opened and closed at least ten more times, with the unit upright, using the local controls.

3.9 Measures, sufficient in capacity to allow the door to be completely closed, are to be taken to ensure that the door can be operated by hand in the event of failure of the power supply.

3.10 Should the central energy supply fail in the local control area of a door, the capability of the other doors to function may not be adversely affected.

3.11 Doors which are closed from the central control station are to be fitted with an audible alarm. Once the door close command has been given this alarm must start at least 5 seconds, but not more than 10 seconds before the door starts to move and continue sounding until the door is completely closed.

3.12 Fire doors are to be fitted with safety strips such that a closing door reopens as soon as contact is made with them. Following contact with the safety strip, the opening travel of the door shall be no more than 1 m.

3.13 Local door controls, including all components, must be accessible for maintenance and adjustment.

3.14 Temperature resistance

3.14.1 The control system must be of approved design. Their capability to operate in the event of fire must be proven in accordance with the FTP-Code and under supervision of GL.

The control system must conform to the following minimum requirements.

3.14.2 The door must still be capable of being operated safely for 60 minutes at a minimum ambient temperature of 200 °C by means of the central energy supply.

3.14.3 The central energy supply for the other doors not affected by fire may not be impaired.

3.14.4 In ambient temperatures in excess of 300 °C the central energy supply must be shut off automatically and the local control system de-energized. The residual energy must still be sufficient to close an open door completely during this process.

The shut-off device must be capable of shutting off the energy supply for one hour with a temperature variation corresponding to the standardized time-temperature curve given in Section II-2, Regulation 30, 4.15 of SOLAS 74.

3.15 The pneumatic system is to be protected against overpressure.

3.16 Drainage and venting facilities are to be provided.

3.17 Air filtering and drying facilities are to be provided.

3.18 For the electrical equipment see Chapter 6 – Electrical Installations.

4. Tests in the manufacturer's works

4.1 Pressure and tightness tests

Section 6, B.5. is applicable as appropriate.

4.2 Final inspection and operational testing

The complete control system is to be subjected to a design approval test to demonstrate that operational capability and design meet the requirements as laid down in 2. and 3.

5. Trials at sea

After installation, the systems are to be subjected to an operational test including emergency operation and verification of the closing times.

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2 IMO Res. MSC.61(67)
Section 9

Jacking Systems

A. General

1. The requirements of this Section apply to the jacking system of self elevating units, compare Chapter 2, Section 2. The electrical installations for the jacking system are defined in Chapter 6, Section 12, I.

2. The jacking system shall be capable of adequately lifting and supporting the unit.

3. The jacking system shall be designed and constructed with sufficient redundancy so that upon failure of any one component, the system shall be capable of continuing to jack or holding in place.

4. The general principle of operation is that the jacking system forms part of the structure of the unit while the legs are free to move up and down in a guide structure. The three or more legs may be individually moved or have to be moved directly coupled by a bottom matt, compare Chapter 2, Section 2. The following jacking systems are considered in these Rules:
   - electrically or hydraulically driven rack and pinion system
   - hydraulic ram and pin system
   - pneumatic rubber block friction system with hydraulic or pneumatic rams

In addition this Section deals with blocking systems:
   - e.g. hydraulic rack and chock system

B. Documents for Approval

The following documents shall be submitted for approval:

- description and general layout plans of the jacking system
- rack and pinion system:
  - detailed drawings of gear elements
  - detailed drawings of rack and pinion with tooth geometry
  - drawings of power transmitting parts, shafts, bearings, couplings and casings, brakes
  - foundation drawings for the gears
- system drawings of hydraulic systems, if applicable
- single line diagram for electric system, if applicable
- ram and pin system:
  - detailed drawing of hydraulic cylinders and control valves as required in Section 8, D.
  - details of pins and their activating mechanism
  - details of the leg chord pin holes
  - system diagram of the hydraulic system
  - details of the hydraulic power pack(s)
  - casing and supporting structure of the system including fixed and movable crossheads
- rubber block friction system:
  - system diagrams of pneumatic and hydraulic systems, if applicable
  - detailed calculations and drawings of the rubber block system to create friction
  - detailed drawings of the ring structure connected to the rubber blocks
  - detailed drawing of hydraulic and pneumatic cylinders and control valves, if applicable
  - details of hydraulic power packs and compressors
  - details of air reservoirs
  - casing and support structure of the system including fixed and movable crossheads and grippers
- details of electrical installations as applicable, compare Chapter 6, Section 12, I.
- operating, control and monitoring system arrangements, see Chapter 6, Section 12, I.
- design calculations
- description and design drawings of blocking system, e.g. rack and chock system:
  - detailed drawings of the chocks with holding teeth
  - detailed drawings of chock activator
  - details of the hydraulic lifting system
  - details of the hydraulic power pack(s)
C. Materials and Design

1. Materials

1.1 The requirements of Chapter 4, Section 4 apply.

1.2 For gears and load bearing component materials see also Section 5.

2. Loads

The design load of the jacking system is the preload. For the definition of the preload capability see Chapter 2, Section 2.

Where the preload is to be created by the drive machinery of the legs, the drive machinery has to be designed for the preload.

Where the preload is created by additional weight of the self elevating unit, e.g. by adding ballast water, the holding capacity of the jacking system or the leg locking system respectively has to be designed for the preload.

The upward (pull out) load has to be defined by the designer of the jacking system.

The maximum static load and the expected number of cycles of jacking operations are to be submitted for evaluation.

3. Rack and pinion system

3.1 Without leg locking system

3.1.1 For self-elevating units without a fixation rack system, the required holding capacity shall be based on the design load. The brake capacity (static friction torque) shall be not less than 1.3 times the design load, considering the mechanical efficiency of the drive gear.

3.1.2 An electric jacking unit shall consist of an electric motor with brake and coupling as well as the reduction gear driving the pinion, which engages on the rack of a leg cord (the main vertical strut), compare Fig. 9.1. A hydraulic jacking unit shall consist of a hydraulic motor with brake, coupling and gear driving the pinion.

3.1.3 The jacking system is to be designed and constructed to maintain the safety of the offshore unit in the event of failure of a critical component during operation of the jacking system. Therefore the jacking system has to consist of multiples of individual lifting elements. At least two pinions with independent drive shall be provided for each cord rack and at least two racks shall be used for one leg.

All pinions and their drives engaged on one rack have to be installed together on a pinion frame, which is mounted on the hull structure. It may become necessary to establish the mounting via shock absorbers at the top and bottom of the pinion frame to reduce environmental impact on the rack/pinion drives.

3.1.4 The strength of gear teeth is to be defined in accordance with Section 5, C. Special attention has to be given to a continuous application of high pressure grease to rack and pinion every time the jacking system is moving.

3.1.5 The control of the jacking drives of the different legs has to be done centrally from a control console in a jacking control station, where also other essential control equipment for operation of the offshore unit shall be installed, compare Chapter 6, Section 12, I. There will be closely defined limits within which the jacking system must be operated, which have clearly to be defined by the manufacturers of the jacking system and included into the Operating Manual.

3.1.6 The motor brake clearances and torques have to be adjusted regularly, otherwise a degrading of the holding power of the jacking system when stopped may occur or the brakes may fail to release when the power is applied on the electric motors. Uneven brake holding power may lead to overload of other pinions and brakes.

3.2 With leg locking system

For self-elevating units with leg locking system the required holding capacity of the fixation system shall be based on the design load. The brake capacity (static friction torque) shall be not less than 1.2 times the design load, mechanical efficiency considered.

3.3 All types of jacking and fixation systems should be protected from environmental influences, i.e. by a jack house at each leg. The house shall be weathertight as far as possible.

4. Ram and pin system

4.1 The required jacking capacity shall be based on the design load. The bearing capacity between pin ends and pin holes shall be not less than 1.3 times the maximum load.

4.2 Normally the fixed crosshead and the movable crosshead shall be provided with at least two pins each. The movable crosshead shall be connected to the hull structure of the unit via at least two hydraulic rams, compare Fig. 9.2.

4.3 The design requirements for the hydraulic system are laid down in Section 8, D.5. The pressure of the hydraulic medium in the cylinders can be directly related to the load on the jacking units at the
different legs and may be used as an information to adjust the loads.

4.4 For the control of the operation see 3.1.5. It has to be safely avoided, that all groups of locking pins get into an unlocked position at the same time.

4.5 The pin holes and the pin ends shall be inspected to check for undue wear or distortion before and after each essential use of the jacking system. Application of high pressure grease is recommended.

5. Rubber block friction system with hydraulic or pneumatic rams

5.1 For the holding capacity between rubber block and shell of the tubular leg shall be at least 1,3 times the design load.

5.2 The rubber block friction system uses the friction between the tubular leg and a greater number of rings of rubber blocks, which are pressed to the shell of the leg by compressed air, see Fig. 9.3. The rubber block rings are to be divided in several groups which are to be separately supplied from the compressed air system providing the contact pressure and for which the actual air pressure has to be monitored. If one group fails the groups remaining operable shall be capable of a holding capacity of 1,0 of the design load. Normally the fixed gripper and the movable gripper shall be provided with a group of rubber block rings. The movable gripper is connected to the hull structure of the unit via at least two hydraulic or pneumatic rams.

5.3 The control system has to permanently monitor the air pressure of the different rubber ring groups and automatically hold the pre-set air pressure. If there is the tendency that the air pressure of a group can only be kept by permanent operation of the compressors, a visible and audible alarm shall be activated. It has to be safely avoided, that all groups of rubber block rings get into a situation without compressed air at the same time.

5.4 General requirements for the pneumatic system

5.4.1 The pneumatic system shall be designed that a single failure, e.g. burst of a pneumatic tube or rupture of supply pipes, etc. does not lead to a complete failure of the system.

5.4.2 Every air intake to the pneumatic system has to be provided with a grid and a filter to avoid the ingress of particles into the system. For operation of the system in areas with excessive humidity a dehumidifier system has to be added.

5.4.3 The requirements for the dimensioning of the piping are defined in Section 13d.

5.4.4 To avoid excessive overpressure safety valves have to be provided. Safety valves must be capable of discharging the air at a maximum pressure increase of 10 % of the allowable working pressure. A safety valve is to be fitted behind each pressure-reducing valve.

5.4.5 The requirements for design and construction of pressure vessels for compressed air are defined in Section 12c.

5.4.6 The test pressure for the pneumatic system including equipment is generally 1,5 times the maximum allowable working pressure PB, subject to a minimum of PB + 1 bar.

5.5 Hydraulic system

If for the rams a hydraulic system is used see 4.3, for the control of operation see 3.1.5.

5.6 Friction

The assumed friction coefficient between the rubber blocks and the shell of the tubular leg has to be agreed with GL. To maintain this coefficient during practical operation, the shell of the tube has to be kept clean and free of oil or grease, etc. A cleaning device at the upper and lower end of a rubber block system is recommended. Before every lifting or lowering operation a check of the leg surface shall be done by the operating personnel.

6. Leg locking system

6.1 For the holding capacity between rack and chock see 3.2.

6.2 The rack/chock system consists normally of rack chocks fitting into the elevator racks, an adjuster and an actuator system, see Fig. 9.4. The blocking system shall be independent from the elevating system and must be sufficiently integrated into the hull structure.

6.3 The teeth of the chocks have to be inspected regularly for undue wear and distortion. Application of high pressure grease is recommended.

7. Leg guides

7.1 The legs must be kept within fairly close limits of lateral movement to ensure proper operation of the jacking systems defined in 3. to 6.

7.2 Two guide levels per leg guide have to be defined in a distance as far as possible from each other. The guides have to be sufficiently integrated into the hull structure and may be fitted with wear plates. The leg guides should be greased with high pressure grease. The condition of the leg guides has to be checked periodically.
Fig. 9.1 Schematic arrangement of a rack and pinion jacking system
Fig. 9.2 Schematic arrangement of a ram and pin jacking system
Fig. 9.3 Schematic arrangement of rubber block friction system
D. Principles of Control and Monitoring

1. Central station

The whole jacking operation shall be commanded from a central control station. In this station all necessary instruments to evaluate the condition and position of the unit before, during and after the jacking operation have to be installed.

In addition instruments to judge the environmental situation have to be incorporated and an overview over the whole unit should be possible from this station. The jacking operation shall only be started or continued if the maximum environmental conditions defined in the Operating Manual are not exceeded.

During the jacking operation the boundary values for the position of the unit, e.g. maximum permissible inclinations, as defined in the Operating Manual shall not be exceeded.

2. Local control stands

Directly at the jacking machinery of each leg shall be a local control stand. This stand shall serve to strictly observe the operation of the jacking machinery at its leg and to detect any malfunction immediately. If such a case would happen, the central control station has to be informed via the permanent communication line immediately and the whole jacking operation has to be stopped from there.

The jacking operation shall only be started, if all local control stands have reported to be free of troubles and ready for starting to the central station.

At this stand the necessary indicators to judge the operation of the machinery of its leg have to be provided.

E. Testing

1. Testing at the manufacturer’s works

1.1 The components of the jacking system shall be shop tested as appropriate.

1.2 For the major components the presence of a GL Surveyor at the testing is required. These components will be defined in the quality control plan.

2. Dock trials

2.1 The completely installed jacking system has to be tested in presence of a GL Surveyor at the building yard.

2.2 The trials shall include at least the following operations:

- leg lowering
- leg lifting
- preloading
- elevation of the unit out of the water
- jacking down and refloating
- pull out of legs, if appropriate.
Section 10

Fire Safety

A. General

1. Governmental Authority

Attention is directed to the appropriate governmental Authority of the country in which the unit or installation is to be registered, operated or installed, as there may be additional requirements depending on the size, type and intended service of the unit or installation as well as other particulars and details.

2. Application

2.1 The requirements in this Section apply to fire safety on fixed offshore installations and mobile offshore units; they are intended to make reference to the International Convention for the Safety of Life at Sea 1974 (SOLAS), as amended and to the MODU Code for the Construction and Equipment of Mobile Offshore Drilling Units, 2001.

2.2 The term “Approved” relates to a material or construction, for which GL has issued an Approval Certificate. A Type Approval Certificate can be issued on the basis of a successful standard fire test, which has been carried out by a neutral and recognized fire testing institute.

3. Definitions

3.1 Non-combustible material

Non-combustible material means 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 to the satisfaction of GL by an established test procedure. Reference is made to the Fire Test Procedure Code, Annex 1, Part 1 adopted by IMO by Resolution MSC.61 (67). Any other material is a combustible material.

3.2 Standard fire test

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. The specimen shall have an exposed surface of not less than 4,65 m² and height (or length of deck) of 2,44 m resembling, as closely as possible, the intended construction and including, where appropriate at least one joint. The standard time-temperature curve is defined by a smooth curve drawn through the following temperature points measured above the initial furnace temperature:

\[
\begin{align*}
\text{at the end of the first 5 minutes:} & \quad 556 °C \\
\text{at the end of the first 10 minutes:} & \quad 659 °C \\
\text{at the end of the first 15 minutes:} & \quad 718 °C \\
\text{at the end of the first 30 minutes:} & \quad 821 °C \\
\text{at the end of the first 60 minutes:} & \quad 925 °C
\end{align*}
\]

3.3 "A" class divisions

"A" class divisions are divisions formed by bulkheads and decks which comply with the following requirements.

3.3.1 "A" class divisions shall be constructed of steel or other equivalent material.

3.3.2 "A" class divisions shall be suitably stiffened.

3.3.3 "A" class divisions shall be so constructed as to be capable of preventing the passage of smoke and flames to the end of the one-hour standard fire test. \(^1\)

3.3.4 "A" class divisions shall be insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 139 °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:

\[
\begin{align*}
\text{Class "A-60"} & \quad 60 \text{ minutes} \\
\text{Class "A-30"} & \quad 30 \text{ minutes} \\
\text{Class "A-15"} & \quad 15 \text{ minutes} \\
\text{Class "A-0"} & \quad 0 \text{ minutes}
\end{align*}
\]

3.4 "B" class divisions

"B" class divisions are divisions formed by bulkheads, decks, ceilings or linings which comply with the following requirements.

3.4.1 "B" class divisions shall be so constructed as to be capable of preventing the passage of flames until the end of the first half of the standard fire test. Reference is made to the Fire Test Procedure Code, Annex 1, Part 3 adopted by IMO by Resolution MSC.61 (67).

\(^{1}\) Reference is made to the Fire Test Procedure Code, Annex 1, Part 3 adopted by IMO by Resolution MSC.61 (67).
3.4.2 "B" class divisions shall have an insulation value such that the average temperature of the unexposed side will not rise more than 139 °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

3.4.3 "B" class divisions shall be constructed of approved non-combustible materials, and all materials entering into the construction and erection of "B" class divisions shall be non-combustible, with the exception that combustible veneers may be permitted, provided they meet other requirements of this Section.

3.5 "C" class divisions

"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 other requirements of this Section.

3.6 Low flame spread

Low flame spread means that the surface thus described will adequately restrict the spread of flame, this being determined to the satisfaction of GL by an established test procedure.2

3.7 Steel or other equivalent material

Where the words "steel or other equivalent material" are used, "equivalent material" means any non-combustible 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).

4. Submission of documents

The following documents shall be submitted in triplicate for approval:

- Plans and documents detailing the relevant control system for the remote closure of fire doors, oil and gas valves.
- Ventilation system plans showing the ducts and fire dampers and the positions of the controls for stopping the system.
- Fire control plans as required in L.1.

5. Elements of approved type

Type "A", "B" and "C" class partitions, fire dampers, insulation materials, linings, ceilings, surface materials and primary deck coverings shall be of approved type.

B. Structural Fire Protection

1. Materials

1.1 The requirements of this Section have been formulated principally for installations/units having their hull, superstructure, structural bulkheads, decks and deckhouses constructed of steel.

1.2 Installations/units constructed of other materials may be accepted, provided that, in the opinion of GL, they provide an equivalent standard of safety.

2. Definitions of spaces

2.1 Control stations

Control stations are those spaces in which the unit’s radio or main navigating equipment or the emergency source of power is located, or where the fire recording or fire control equipment or the dynamical positioning control system is centralized, or where a fire extinguishing system serving various locations or a central ballast control station is situated. In the application of this Section, however, the space where the emergency source of power is located is not considered as being a control station.

2.2 Corridors

Corridors mean corridors and lobbies.

2.3 Accommodation spaces

Accommodation spaces are those used as public spaces, corridors, lobbies, bars, offices, hospitals, cinemas, games and hobbies rooms, pantries containing no cooking appliances and similar spaces. Public spaces are those portions of the accommodation which are used for halls, dining rooms, lounges, and similar permanently enclosed spaces.

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2 Reference is made to the Fire Test Procedure Code, Annex 1, Parts 2 and 5 adopted by IMO by Resolution MSC.61 (67).
2.4 Stairways

Stairways are interior stairways, lifts 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.

2.5 Service spaces (low risk)

Service spaces (low risk) are lockers, store rooms and working spaces, in which no flammable materials are stored, drying rooms and laundries.

2.6 Machinery spaces of category A

Machinery spaces of Category A are all spaces which contain internal combustion type machinery used either
- for main propulsion; or
- for other purposes, where such machinery has in the aggregate a total power of not less than 375 kW

or machinery spaces which contain any oil-fired boiler or oil fuel units; and trunks to such spaces.

2.7 Other machinery spaces

Other machinery spaces are all machinery spaces except those of Category A containing propelling machinery, boilers and other fired process equipment, 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.

2.8 Hazardous areas

Hazardous areas are all those areas where, due to the possible presence of a flammable atmosphere arising from the drilling or process operations, the use without proper consideration of machinery or electrical equipment may lead to fire hazard or explosion. See also Section 2, B.

2.9 Service spaces (high risk)

Service spaces (high risk) are lockers, store rooms and working spaces in which flammable materials are stored, galleys, pantries containing cooking appliances, paint rooms and workshops other than those forming part of the machinery space.

2.10 Open decks

Open decks are open deck spaces, excluding hazardous areas.

2.11 Sanitary and similar spaces

Sanitary and similar spaces are communal sanitary facilities such as showers, baths, lavatories, etc. and isolated pantries containing no cooking appliances. Sanitary facilities which serve a space and which have an access only from that space, shall be considered as a portion of the space in which they are located.

3. Fire integrity of bulkheads and decks

3.1 In addition to complying with the specific provisions for fire integrity of bulkheads and decks in this section, the minimum fire integrity of bulkheads and decks shall be as prescribed in Tables 10.1 and 10.2.

Exterior boundaries of superstructures and deckhouses enclosing accommodation, including overhanging decks which support such accommodation, shall be constructed to A-60 standard for the whole of the portion which faces and is within 30 m of the centre of the rotary table of drilling installations/units. Where there is a movable substructure the 30 m shall be measured with the substructure at its closest drilling position to the accommodation. GL may accept equivalent arrangements.

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.

3.2 Application of the Tables

3.2.1 Tables 10.1 and 10.2 apply respectively to the bulkheads and decks separating adjacent spaces.

3.2.2 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 2.1 to 2.11. The title of each category is intended to be typical rather than restrictive.

The number preceding each category under 2. above refers to the applicable column or row in the Tables.

4. Structural requirements for doors, windows, stairways, ceilings, linings, etc.

4.1 Fire and external doors

External doors in superstructures and deckhouses shall be constructed to "A-0" class division and be self-closing, where practicable. The construction of all doors and frames in "A" class divisions, including the means of securing them when closed, shall provide resistance to fire as well as to the passage of smoke and flames, as far as practicable, equivalent to that of the bulkheads in which the doors are situated. Such doors and door frames shall be constructed of steel or other equivalent material. Doors in "A" class
divisions must be capable of being opened and closed from each side of the bulkhead by one person only.

4.2 Intersections

In approving fire protection details, GL will have regard to the risk of heat transmission at intersections and thermal points of required thermal barriers.

Where "A" class divisions are pierced for the passage of electric cables, pipes, trunks, ducts, etc., or for girders, beams or other structures, arrangements shall be made to ensure that the fire resistance is not impaired.

4.3 Windows and sidescuttles

Windows and sidescuttles with the exception of navigating bridge windows, shall be of the non-opening type. Navigating bridge windows may be of the opening type, provided the design of such windows would permit rapid closure. GL permits windows and sidescuttles outside hazardous areas to be of the opening type.

4.4 Surroundings of drill floor

4.4.1 Windows and sidescuttles which face the drill floor, with the exception of the wheelhouse windows (where applicable), shall be:

- constructed to an "A-60" standard
- protected by a water curtain, or
- fitted with shutters of steel or equivalent material

Table 10.1 Fire integrity of bulkheads separating adjacent spaces

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<tr>
<th>Spaces</th>
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Remarks

1 Where the space contains an emergency power source or components of an emergency power source adjoining a space containing a service generator or the components of a service generator, the boundary bulkhead or deck between those spaces shall be an A-60 class division.

2 For clarification as to which note applies see 4.5 and 4.7.

3 Where spaces are of the same numerical category and superscript 3 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 1.9. A galley next to a galley does not require a bulkhead but a galley next to a paint room requires an A-0 bulkhead.

4 Bulkheads separating the navigating bridge, chartroom and radio room from each other may be B-0 rating.

5 The division is required to be of steel or equivalent material, but need not be of A class standard.
4.4.2 Exterior boundaries of superstructures and
deckhouses enclosing accommodation, including any
overhanging decks which support such accommodation,
shall be constructed to "A-60" standard for the
whole of the portion which faces, and in within 3
metres of the centre of the rotary table, and on the
side and top portions for a distance of not less than 3
metres from the portions which face the drill floor
area. GL may accept equivalent arrangements.

4.5 Corridors

All bulkheads required to be "B" class divisions shall
extend from deck to deck and to the deckhouse side
or other boundaries, unless continuous "B" class
ceilings or linings are fitted on both sides of the bulk-
head, in which case the bulkhead may terminate at
the continuous ceiling or lining.

In corridor bulkheads, ventilation openings may be
permitted only in and under the doors of cabins, pub-
lic spaces, offices and sanitary spaces. The openings
shall be provided only in the lower half of the 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 m². When such an opening is cut in a
door it shall be fitted with a grille made of non-
combustible material. Such openings shall not be
provided in a door in a division forming a stairway
closure.

4.6 Stairs

Stairs shall be constructed of steel or equivalent ma-
terial.

4.7 Stairways and lifts

Stairways which penetrate only a single deck shall be
protected at least at one level by "A" or "B" Class
divisions and self-closing doors so as to limit the
rapid spread of fire from one deck to another.

Stairways and lift shafts which penetrate more than a
single deck shall be surrounded by "A" class divi-
sions and protected by self-closing doors at all levels.
Self-closing doors shall not be fitted with hold-back
hooks. However, hold-back arrangements incorporat-
ing remote release fittings of the fail-safe type may
be utilized.

Personnel lift trunks shall be protected by "A" class
divisions.

Table 10.2  Fire integrity of decks separating adjacent spaces

<table>
<thead>
<tr>
<th>Spaces below</th>
<th>Spaces above 2.1</th>
<th>2.2</th>
<th>2.3</th>
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</tbody>
</table>

Remarks

1 Where the space contains an emergency power source or components of an emergency power source adjoining a
service generator or the components of a service generator, the boundary bulkhead or deck between those spaces shall be an A-60 class
division.

2 Where spaces are of the same numerical category and superscript 3 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 2.9. A galley next to a galley does not require a
bulkhead but a galley next to a paint room requires an A-0 bulkhead.

3 The division is required to be of steel or equivalent material, but need not be of A class standard. However, where a deck is penetrated
for the passage of electric cables, pipes and vent ducts, such penetrations shall be made tight to prevent the passage of flame and
smoke.
4.8 Air spaces

Air spaces enclosed behind ceilings, panellings or linings shall be divided by close fitting draught stops spaced not more than 14 metres apart.

4.9 Except for insulation in refrigerated compartments, insulation material, pipe and vent duct lagging, ceilings, linings and bulkheads shall be of non-combustible material, see A.3.1. Insulation of pipe fittings for cold service systems and vapour barriers and adhesives used in conjunction with insulation need not be non-combustible but they shall be kept to a minimum and their exposed surfaces should have low flame spread characteristics. In spaces where penetration of oil products is possible, the surfaces of the insulation shall be impervious to oil or oil vapours.

4.10 Framing

The framing, including supports and the joint pieces of bulkheads, linings, ceilings and draught stops, shall be of non-combustible material.

4.11 Surfaces

The following surfaces shall have low flame spread characteristics, see A.3.1:

- exposed surfaces in corridors and stairway enclosures
- surfaces in concealed or inaccessible spaces in accommodation, service spaces and control stations
- exposed surfaces of ceilings in accommodation, service spaces and control stations

4.12 Veneers

Bulkheads, linings and ceilings may have combustible veneers provided that the thickness of such veneers shall not exceed 2 mm within any space other than corridors, stairway enclosures and control stations, where the thickness should not exceed 1.5 mm. Alternatively veneers which have a calorific value not exceeding 45 mJ/m² of the area for the thickness used may be accepted by GL, irrespective of the thickness of those veneers.

4.13 Deck coverings

Primary deck coverings, if applied, shall be of approved materials, which will not readily ignite or give rise to toxic or explosive hazards at elevated temperatures.

4.14 Paints and varnishes

Paints, varnishes and other finishes used on exposed interior surfaces shall not offer an undue fire hazard in the judgement of GL and shall not be capable of producing excessive quantities of smoke or toxic fumes.

5. Ventilation

5.1 Materials

Ventilation ducts shall be of non-combustible material. Short ducts, however, not generally exceeding 2 m in length and with a cross-sectional area not exceeding 0.02 m² need not be non-combustible, subject to the following conditions:

- these ducts shall be of a material which, in the opinion of GL, has a low fire risk
- they may only be used at the end of the ventilation device
- they shall not be situated less than 600 mm, measured along the duct, from where it penetrates any "A" or "B" class division including continuous "B" class ceilings

5.2 Ducts

Where ventilation ducts with a cross-sectional area exceeding 0.02 m² pass through class "A" bulkheads or decks, the opening shall be lined with a steel sheet sleeve unless the ducts passing through the bulkheads or decks are of steel in the vicinity of penetrations through the deck or bulkhead, the ducts and sleeves at such places shall comply with the following:

5.2.1 The ducts or 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 passes. Equivalent penetration protection shall be provided to the satisfaction of GL.

5.2.2 Ducts with a cross-sectional area exceeding 0.075 m², except those serving hazardous areas, shall be fitted with fire dampers in addition to meeting the requirements of 5.2.1. The fire damper shall operate automatically but shall also be capable of being closed 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, provided those ducts have the same fire integrity as the divisions which they pierce. GL may, given special considerations, permit operation from one side of a division only.

5.2.3 A full cross-sectional area of a duct is to be considered for the above requirements. Splitting of

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3 Reference is made to the Fire Test Procedure Code, Annex 1, Part 5 adapted by IMO by Resolution MSC.61 (67).

4 Reference is made to the Fire Test Procedure Code, Annex 1, Parts 2 and 6 adopted by IMO by Resolution MSC.61 (67).
ducts before the penetration and merging afterwards does not relax the requirements.

5.3 Ventilation of machinery spaces, galleys and hazardous areas

Ducts provided for the ventilation of machinery spaces of category "A", galleys and hazardous areas shall not pass through accommodation spaces, service spaces or control stations. However, GL may permit a relaxation from this requirement, except for the ducts serving hazardous areas passing through accommodation spaces, control stations and galleys, provided that:

5.3.1 Ducts are constructed of steel having a thickness of at least 3 mm for ducts of 300 mm in width or less and of at least 5 mm for ducts of 760 mm in width and over; in the case of ducts the width or diameter of which is between 300 mm and 760 mm, the thickness shall be obtained by interpolation.

5.3.2 Ducts are fitted with automatic fire dampers close to the boundaries penetrated, and

5.3.3 Ducts are insulated in "A-60" standard from the machinery spaces or galleys to a point at least 5 m beyond each fire damper.

Or alternatively:

5.3.4 Ducts are constructed of steel in accordance with 5.3.1.

5.3.5 Ducts are insulated to "A-60" standard throughout the accommodation spaces, service spaces or control stations.

5.4 Ventilation of accommodation spaces, service spaces or control stations

Ducts provided for the ventilation of accommodation spaces, service spaces or control stations shall not pass through machinery spaces of category A, galleys or hazardous areas. However, GL may permit a relaxation from this requirement, except for the ducts passing through hazardous areas, provided that:

5.4.1 The ducts where they pass through a machinery space of category A or a galley are constructed of steel in accordance with 5.3.1.

5.4.2 Automatic dampers are fitted close to the boundaries penetrated.

5.4.3 The integrity of the machinery space or galley boundaries is maintained at the penetrations.

Or alternatively:

5.4.4 The ducts where they pass through a machinery space of category A or a galley are constructed of steel in accordance with 5.3.1.

5.4.5 Ducts are insulated to "A-60" standard within the machinery space or galley.

5.5 Ducts passing "B" class bulkheads

Ventilation ducts with a cross-sectional area exceeding 0.02 m² 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 bulkhead unless the duct is of steel for this length.

5.6 Ducts from galley ranges

Where they pass through accommodation spaces or spaces containing combustible materials, the exhaust ducts from galley ranges shall be of equivalent fire integrity to "A" class divisions. Each such exhaust duct shall be fitted with:

− a grease trap readily removable for cleaning
− a fire damper located in the lower end of the duct
− arrangements, operable from within the galley, for shutting off the exhaust fans, and
− fixed means for extinguishing a fire within the duct.

5.7 Inlets and outlets

The main inlets and outlets of all ventilation systems shall be capable of being closed from outside the spaces being ventilated.

5.8 Power ventilation

Power ventilation of accommodation spaces, service spaces, control stations, machinery spaces and hazardous areas shall be capable of being stopped from an easily accessible position outside the space being served. The accessibility of this position in the event of a fire in the spaces served shall be specially considered. The means provided for stopping the power ventilation serving machinery spaces or hazardous areas shall be entirely separate from the means provided for stopping ventilation of other spaces.

5.9 Accommodation spaces and control stations

The ventilation of the accommodation spaces and control stations shall be arranged in such a way as to prevent the ingress of flammable, toxic or noxious gases or smoke from surrounding areas.

6. Means of escape

6.1 Accommodation spaces, service spaces and control stations

Within the accommodation spaces, service spaces and control stations the following requirements shall be applied:
6.1.1 In every general area which is likely to be regularly manned or in which personnel are accommodated at least two separate escape routes shall be provided, situated as far apart as practicable, to allow ready means of escape to the open decks and embarkation stations. Exceptionally, GL may permit only one means of escape, due regard paid to the nature and location of spaces and to the number of persons who might normally be accommodated or employed there.

6.1.2 Stairways shall normally be used for means of vertical escape, however, a vertical ladder may be used for one of the means of escape when the installation of a stairway is shown to be impracticable.

6.1.3 Every escape route shall be readily accessible and unobstructed and all exit doors along the route shall be readily operable. Dead-end corridors exceeding 7 m in length shall not be permitted.

6.2 Machinery spaces of category A
Two means of escape shall be provided from every machinery space of category A by one of the following:

6.2.1 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. In general, one of these ladders shall provide continuous fire shelter from the lower part of the space to a safe position outside the space.

However, GL may not require the shelter if, due to the special arrangement or dimensions of the machinery space, a safe escape route from the lower part of this space is provided. This shelter shall be fitted of steel, insulated, where necessary, to the satisfaction of GL and be provided with a self-closing steel door at the lower end, or:

6.2.2 One 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.

Exceptionally, GL may require only one means of escape, due regard being paid to the nature and location of spaces and to the number of persons who might normally be employed there.

6.3 Machinery spaces other than category A
From machinery spaces other than those of category A, escape routes shall be provided to the satisfaction of GL having regard to the nature and location of the space and whether persons are normally employed there.

6.4 Lifts
Lifts shall not be considered as forming one of the required means of escape.

6.5 Embarkation

6.5.1 Consideration will be given by GL to the siting of superstructures and deckhouses such that in the event of fire at the drill floor at least one escape route to the embarkation position and survival craft is protected against radiation effects of that fire as far as practicable.

6.5.2 Lifeboat embarkation stations and the access routes to them shall be sufficiently protected to withstand a fire long enough to enable the crew to abandon the platform or unit.

C. Fire Fighting, Fire Detection and Gas Detection
Every offshore unit/installation is to be provided with a fire and deckwash system according to D.1. Furthermore, fire hazard areas are to be provided with fire fighting, fire detection and gas detection equipment according to Table 10.3.

D. Water Fire Extinguishing Systems

1. Fire and deckwash system

1.1 Fire pumps

1.1.1 At least two independently driven power pumps have to be provided, each arranged to draw directly from the sea and discharge into a fixed fire main. However in cases with high suction lifts, booster pumps and storage tanks may be installed, provided such arrangements will satisfy all the requirements of 1.1.1 to 1.1.10. At least one of the required pumps is to be dedicated to fire fighting duties only and shall be available for such duties at all times.

1.1.2 The pumps, their power supply and the associated pipes and valves are to be so arranged that a fire in any space does not involve the failure of all the fire pumps.

1.1.3 Each pump shall be capable of delivering at least one jet simultaneously from each of any two fire
hydrants, hoses and 19 mm nozzles while maintaining a minimum pressure of 0.35 N/mm² at any hydrant.

In addition, where a foam system is provided for protection of the helicopter deck, the pump shall be capable of maintaining a pressure of 0.7 N/mm² at the foam installation. If the water consumption for any other fire protection or fire-fighting purpose should exceed the rate of the helicopter deck foam installation, this consumption shall be the determining factor in calculating the required capacity of the fire pumps.

1.1.4 The capacity of the required pumps shall be appropriate to the fire fighting services supplied from the fire main. The capacity of each pump is not to be less than 70 m³/h.

1.1.5 Centrifugal pumps used as fire pumps are to be connected to the fire main by means of screw-down-non-return valves or a combination of non-return and shut-off valve.

1.1.6 Relief valves are to be provided in conjunction with all pumps connected to the fire main, if the pumps are capable of developing a pressure exceeding the design pressure of the fire main, hydrants and hoses. Closure of any single isolating valve or combination of isolating valves shall not leave any part of the main unprotected against overpressure.

1.1.7 The water supply for the fire main should be drawn directly from the sea and only self-priming pumps shall be installed. However, in installations/units with high suction lifts, booster pumps and intermediate storage tanks may be installed.

1.1.8 Where either of the required pumps is located in a space not normally manned and relatively far away from working areas, provisions are to be made for remote start-up of the pump and remote operation of associated suction and discharge valves.

1.1.9 Except as provided in 1.1, sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil.

1.1.10 Fire pumps shall start automatically when there is a pressure drop in the firewater main.

1.2 Fire mains

1.2.1 A fixed fire main shall be provided. For design and construction of all pipes see Section 13d.

1.2.2 The diameter of the fire main and water service pipes shall be sufficient for the effective distribution of the maximum required discharge from the required fire pumps operating simultaneously.

1.2.3 With the required fire pumps operating simultaneously, the pressure maintained in the fire mains shall be adequate for the safe and efficient operation of all equipment supplied therefrom.

1.2.4 The fire main is to be routed clear of hazardous areas as far as practicable and be arranged in such a manner as to make maximum use of any thermal shielding or physical protection afforded by the structure of the unit.

1.2.5 The fire main shall be provided with isolating valves located so as to permit optimum utilization in the event of physical damage to any part of the main.

1.2.6 The fire main shall not have connections other than for fire-fighting purposes.

1.2.7 All practical precautions should be taken to protect the fire main against freezing, in order to have water readily available.

1.2.8 Materials readily rendered ineffective by heat shall not be used for fire mains and hydrants unless adequately protected. Hydrants shall be so placed that the fire hoses may be easily connected.

1.2.9 A cock or valve is to be fitted to serve each fire hose so that any fire hose may be removed while the fire pumps are at work.

1.3 Monitors, hydrants, hoses and nozzles

1.3.1 The unit or installation shall be equipped with a sufficient number of strategically located monitors, hydrants, hose stations and fire hose reels.

1.3.2 Monitors

1.3.2.1 Monitors (for water or foam) shall be provided with sufficient movement horizontally and vertically to cover the hazardous areas of Zones 1 and 2 in open areas, compare Section 2. The monitor shall be provided with a locking device for operating in a selected position.

1.3.2.2 The capacity and number of the monitors is to be sufficient to deliver at least 6 l/m²/min at a nozzle pressure of 5 bar. Each monitor shall be capable of discharging under jet and spray conditions.

1.3.2.3 Monitors shall be easily accessible also during a fire.

1.3.3 Hydrants

Hydrants are to be so distributed, that at least two water jets not emanating from the same hydrant can reach any point of the platform which would normally be accessible to the crew. One jet may be delivered by a single length of hose and the second by a joint hose length of not more than 30 m.
<table>
<thead>
<tr>
<th>Areas and spaces to be protected</th>
<th>Fire fighting equipment</th>
<th>Fire detection system</th>
<th>Gas detection system</th>
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<td>Permanent installed fire extinguishing systems</td>
<td>Portable and mobile extinguishing equipment</td>
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<td>spraying system</td>
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<td>and cement</td>
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<td>or low expansion foam</td>
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**Remarks:** For fixed production installations a water cooling system for the substructure may have to be provided. 1) Means: refer to text 3) Water extinguishers may be used 3) Alternatively systems using gases other than CO₂ may be applied.
1.3.4 Fire hoses

Fire hoses shall be of an approved type and be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Their maximum length should not exceed 15 m.

Every fire hose shall be provided with a dual purpose nozzle and the necessary couplings, and together with any necessary fittings and tools be kept ready for use in conspicuous positions near the water service hydrants or connections.

1.3.5 Nozzles

Nozzles shall comply with the following requirements:

- Standard nozzle sizes should be 12 mm, 16 mm and 19 mm or as near thereto as possible. Under special circumstances the use of larger nozzles may be considered.
- For accommodation and service spaces, a nozzle size greater than 12 mm need not be used.
- For machinery and exterior locations, the nozzle size shall be 19 mm.

2. Fixed pressure water systems for fire fighting and cooling

2.1 Deluge systems

2.1.1 Gas or oil processing facilities and storage areas, which require water protection, should be covered by deluge systems and/or monitors. The deluge system shall discharge water through all nozzles at the same time and will be started automatically or manually by opening the deluge valve. Where deluge systems are installed, the following requirements apply.

2.1.2 The nozzles are to be of an approved type. The number and arrangement of the nozzles is to be such as to ensure an effective average distribution of water of at least 5 l/m² per minute in the spaces to be protected.

2.1.3 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, not likely to be cut off by a fire in the protected space.

2.1.4 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.

2.1.5 The pump shall be capable of simultaneously supplying at the necessary pressure all sections of the system in any one compartment to be protected. 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 waterspraying system to put the system out of action.

2.1.6 The pump may be driven by an independent internal combustion engine but, if it is dependent upon power being supplied from the emergency generator, that generator shall be so arranged as to start automatically in case of main power failure, so that power for the pump required by 2.1.5 is immediately available. When the pump is driven by an independent internal combustion engine, it shall be so situated that a fire in the protected space will not affect the air supply to the engine.

2.1.7 Precautions shall be taken to prevent the nozzles from becoming clogged by impurities in the water or by corrosion of piping, nozzles, valves and pump.

2.1.8 For production plants with high protection requirements, when a jet fire may occur, very short respond times of the deluge system will become necessary and have to be agreed with GL.

2.1.9 Suitable provisions shall be made for the system to be tested without detracting from its operational efficiency or disrupting the operational routine of the installation.

2.1.10 Upon use of the system, an audible and visual alarm is to be activated in the control centre, indicating the section affected.

2.2 Automatic sprinkler systems

2.2.1 Every normally manned offshore installation/unit shall be provided with an automatic sprinkler system for the accommodation spaces. This system shall apply fire-extinguishing water through nozzles if heat is detected and is charged with pressurized water up to every nozzle. Only fire exposed nozzles will discharge water, but also a fire alarm has to be initiated.

2.2.2 Each sprinkler section is to be equipped with an alarm valve which, when a sprinkler is activated, actuates a visual and audible alarm at the control centre, indicating the section concerned. A pressure gauge is to be provided at each section.

The electrical equipment shall be self-monitoring and each section shall be capable of being tested individually.

2.2.3 The system is normally to be supplied by a pressurized fresh water system, capable, once actuated, of operating automatically for 4 hours at a sufficient water pressure to enable it to operate efficiently.

2.2.4 In the event of a pressure drop in the system, a pressure water pump used solely for this purpose shall start up automatically before the pressure water tank has been exhausted.

Suitable means for testing are to be provided.

5 Water mist systems which are type approved in accordance with IMO Res. A.800(19) may be used.
2.2.5 The pressure water tank and sprinkler pump are to be located in a safe area outside the spaces to be protected.

2.2.6 A changeover arrangement to a fire water main shall be provided.

2.2.7 Piping shall be heat-resistant and shall be either inherently corrosion-resistant or be suitably protected against corrosion.

2.2.8 The spray nozzles are to be grouped into sections. They are to be so arranged, that not less than 5 l/m²/min is sprayed over the area to be protected.

Inside the accommodation spaces the nozzles shall be activated within a temperature range of 68 °C to 79°C.

The nozzles are to be made of corrosion-resistant material. Nozzles of galvanized steel are not permitted.

2.2.9 Suitable means for calibration and testing of the system are to be provided.

E. Foam Fire Extinguishing Systems

1. Foam type

Only approved foam concentrates are to be used. The systems shall be protected against freezing.

2. High expansion foam

2.1 High expansion foam systems for the protection of enclosed spaces are to be so designed, that the largest space to be protected can be filled with foam at the rate of at least 1 m depth per minute without allowance for machinery and equipment. The supply of foam solution shall be sufficient to fill completely at least 5 times the largest space to be protected. The expansion ratio of the foam shall not exceed 1000 : 1.

2.2 Foam generator

The foam generator with tanks, pipe system, ducts, etc. is to be permanently installed and shall be capable to attain full foam production within 2 minutes after fire alarm.

The foam generator with equipment is to be placed in a safe area, separated from areas to be protected. If there is no access from the open deck, two separate means of access are to be provided.

2.3 Foam ducts

The foam ducts are to be dimensioned according to the size of the foam generator outlet, and are to be so located, that an even distribution of foam is obtained throughout the room to be protected. The ducts are to be made of steel and protected against corrosion.

A shut-off device is to be fitted between the foam generator and the distribution system.

3. Low expansion foam

3.1 Enclosed spaces

If low expansion foam is used for local protection in enclosed spaces, the system is to be so designed, that the largest area over which fuel can spread, can be covered within 5 minutes with a 150 mm thick layer of foam. The expansion ratio shall not exceed 12 : 1.

3.2 Exterior locations

3.2.1 Fixed low-expansion foam systems for use in exterior locations shall be capable of supplying foam solution to the monitors and foam applicators at a rate which shall be at least the greater of the following quantities, but not less than 1250 l/min:

a) 0,6 l/min per square meter of the total area to be protected
b) 1,5 l/min per square meter of a circular area with the radius of 75 % of the nominal length of throw of the largest monitor provided.

3.2.2 Foam capacity

The supply of foam concentrate is to be sufficient for at least 30 minutes of operation of the system at maximum capacity as specified in 3.2.1.

3.2.3 Foam monitors

Foam monitors are to be so arranged that the protected area can be covered from at least two monitors, which shall as far as practicable be located opposite to each other.

3.3 Foam hydrants

Foam hydrants are to be so arranged that any part of the protected area can be reached with at least one foam applicator and hose.

One foam hydrant is to be arranged at the access to any area to be protected. The total of foam applicators available shall not be less than four.

3.4 Location of the system

3.4.1 Foam storage tanks, associated pumps, proportioners and controls shall be located in a safe area not likely to be cut off in the event of a fire in a protected area.

The system is to be designed for rapid readiness.

3.4.2 In centralized systems shut-off valves are to be provided in order to isolate damaged sections of the foam main.
4. Influence to water fire fighting

The operation of the foam system shall not impair the simultaneous use of any water fire fighting installation required by these Rules.

F. Fixed Gas Fire Extinguishing Systems

1. CO₂ fire extinguishing systems

1.1 Initiation

The system is to be arranged for manual initiation of release only.

1.2 Design

CO₂ cylinders, associated pressure components and piping shall be approved in respect of materials, design and manufacture. Special attention is to be paid to the risk of icing of quick-flooding lines.

1.3 Pipes

1.3.1 The pipes for conveying the gas shall be provided with control valves so marked, as to indicate clearly the compartments to which the pipes are led.

1.3.2 Wherever possible, welded pipe connections are to be used for CO₂ systems. For detachable connections which cannot be avoided and for valves and fittings, flanged joints are to be used. For pipes with a nominal bore of less than 50 mm, welded compression type couplings may be used. Threaded joints may be used only inside protected spaces.

1.3.3 Pipe materials and wall thickness have to be selected according to Section 13d.

1.3.4 All pipes are to be suitably protected against corrosion.

1.3.5 In piping sections where valve arrangements introduce sections of closed piping (e.g. manifolds with distribution valves), such sections shall be fitted with a pressure relief valve and the outlet of the valve shall be led to the open deck.

1.4 Valves and fittings

Valves and fittings in the lines from the cylinders to the control valves have to be designed for a nominal pressure of 100 bar, the lines from the control valves to the nozzles for a nominal pressure of 40 bar.

1.5 Nozzles

Discharge nozzles and piping shall be arranged so as to provide effective distribution of gas.

1.6 Quantity of gas

1.6.1 The quantity of gas carried shall be sufficient to give a minimum quantity of free gas equal to 35 % of the entire volume of the largest space to be protected. If two or more adjacent spaces protected by CO₂ are not entirely separate, they shall be considered as forming one space.

1.6.2 The calculation is to be based upon a gas volume of 0,56 m³ per kg of CO₂.

1.6.3 The system is to be so designed that 85 % of the required gas can be discharged into the space within 2 minutes.

1.7 Gas storage

1.7.1 Gas cylinder storage rooms or areas shall be situated at a safe and readily accessible position and be effectively ventilated, compare K. Any entrance to storage rooms should preferably be from the open deck and in any case shall be independent of the protected space. Access doors shall be gastight and open outward. Bulkheads and decks, which form the boundaries of such rooms, shall be gastight and adequately insulated to prevent a temperature exceeding 45 °C inside the CO₂ room. Any of the boundaries which are contiguous with the protected space are to be A-60 Class divisions.

1.7.2 Pressure relief devices associated with CO₂ cylinders, tanks or manifolds are to be so arranged, that when operated there will be no danger to personnel from the resultant discharge of CO₂.

1.7.3 Provision is to be made for changing the cylinders and checking the contents by weighing or by other approved means.

1.8 Warning

Means shall be provided for the automatic giving off audible and visual warning of the release of CO₂ gas into any space to which personnel normally has access. The alarm shall operate before the gas is released for a period of time suitable to evacuate the space to be flooded, but not less than 20 s.

1.9 Control

The means of control of any such fixed gas fire extinguishing system shall be readily accessible and simple to operate and shall be located in a release box in a safe area outside the protected space. Two controls shall be provided, one for opening the distribution valve and one for opening the CO₂ gas cylinders.

1.10 Ventilation

Means shall be provided for stopping all ventilation fans and closing openings serving the protected spaces, before the medium is released.

1.11 Arrangement plan

A general arrangement plan has to be exhibited in the Control Centre, the operating stations and the CO₂ rooms, showing the arrangement of the CO₂ system.
1.12 Warning signs
Warning signs shall be displayed at the access(es) to the CO₂ room and to spaces protected by the system.

1.13 Tests
After completion of the system, pressure and tightness tests in accordance with Section 13a – 13e and free passage tests have to be performed.

2. Extinguishing systems using gases other than CO₂

2.1 General

2.1.1 Suppliers for the design and installation of fire extinguishing systems using extinguishing gases other than CO₂ are subject to special approval by GL ⁶.

2.1.2 Systems using extinguishing gases other than CO₂ shall be approved in accordance with a standard acceptable to GL.

2.1.3 No fire extinguishing gas shall be used which is carcinogenic, mutagenic or teratogenic at concentrations expected during its use or which is not considered to be environmentally acceptable.

No fire extinguishing gas shall be used in concentrations greater than the cardiac sensitisation level NOAEL (No Observed Adverse Effect Level), without the use of the release arrangements and alarms as provided in 2.6.

In no case an extinguishing gas is permitted to be used in concentrations above its LOAEL (Lowest Observed Adverse Effect Level) nor its ALC (Approximate Lethal Concentration).

2.1.4 New installations of halogenated hydrocarbon (halon) systems are not permitted.

2.1.5 For systems using halocarbon clean agents, the system shall be designed for a discharge of 95 % of the design concentration in not more than 10 s.

For systems using inert gases, the discharge time shall not exceed 120 s for 85 % of the design concentration.

2.2 Calculation of the supply of extinguishing gas

2.2.1 The supply of extinguishing gas shall be calculated based on the net volume of the protected space, at the minimum expected ambient temperature using the design concentration specified in the system's type approval Certificate.

2.2.2 The net volume is that part of the gross volume of the space which is accessible to the free extinguishing gas including the volumes of the bilge and of the casing. Objects that occupy volume in the protected space shall be subtracted from the gross volume. This includes, but is not necessarily limited to:

- internal combustion engines
- reduction gear
- boilers
- heat exchangers
- tanks and trunks
- exhaust gas pipes, -boilers and -silencers

2.2.3 The volume of free air contained in air receivers located in a protected space shall be added to the net volume unless the discharge from the safety valves is led to the open air.

2.2.4 In systems with centralised gas storage for the protection of more than one space the quantity of extinguishing gas available need not be more than the largest quantity required for any one space so protected.

2.3 Gas containers

2.3.1 Containers for the extinguishing gas or a propellant needed for the discharge shall comply in respect of their material, construction, manufacture and testing with the relevant GL Rules on pressure vessels.

2.3.2 The filling ratio shall not exceed that specified in the system's type approval documentation.

2.3.3 Means are to be provided for the installation's/unit's personnel to safely check the quantity of medium in the containers.

2.4 Storage

2.4.1 Centralised systems

Gas containers in centralised systems are to be stored in a storage space complying with the requirements for CO₂ storage spaces, see 1.7, with the exception that storage temperatures up to 55 °C are permitted, unless otherwise specified in the type approval Certificate.

2.4.2 Modular systems

2.4.2.1 All systems covered by these requirements may be executed as modular systems with the gas containers, and containers with the propellant if any, permitted to be stored within the protected space providing the conditions of 2.4.2.2 through 2.4.2.9 are complied with.

2.4.2.2 Inside a protected space, the gas containers shall be distributed throughout the space with bottles or groups of bottles located in at least six separate locations. Duplicate power release lines have to be arranged to release all bottles simultaneously. The

⁶ Refer to IMO MSC/Circ. 848, “Revised Guidelines for the Approval of Equivalent Fixed Gas Fire Extinguishing Systems, as referred to in SOLAS 74, for Machinery Spaces and Cargo Pump Rooms”.
release lines shall be so arranged that in the event of damage to any power release line, five sixth of the fire extinguishing gas can still be discharged. The bottle valves are considered to be part of the release lines and a single failure shall include also failure of the bottle valve.

For systems that need less than six containers (using the smallest bottles available), the total amount of extinguishing gas in the bottles shall be such that in the event of a single failure to one of the release lines (including bottle valve), five sixth of the fire extinguishing gas can still be discharged. This may be achieved by for instance using more extinguishing gas than required so that if one bottle is not discharging due to a single fault, the remaining bottles will discharge the minimum five sixth of the required amount of extinguishing gas. This can be achieved with minimum two bottles. However, the NOAEL value calculated at the highest expected engine room temperature may not be exceeded when discharging the total amount of extinguishing gas simultaneously.

Systems that cannot comply with the above (for instance where it is intended to locate only one bottle inside the protected space) are not permitted. Such systems shall be designed with bottle(s) located outside the protected space, in a dedicated room complying with the requirements for CO₂ storage spaces (see 1.7).

2.4.2.3 Duplicate sources of power located outside the protected space shall be provided for the release of the system and be immediately available, except that for machinery spaces, one of the sources of power may be located inside the protected space.

2.4.2.4 Electric power circuits connecting the containers shall be monitored for fault conditions and loss of power. Visual and audible alarms shall be provided to indicate this.

2.4.2.5 Pneumatic or hydraulic power circuits connecting the containers shall be duplicated. The sources of pneumatic or hydraulic pressure shall be monitored for loss of pressure. Visual and audible alarms shall be provided to indicate this.

2.4.2.6 Within the protected space, electrical circuits essential for the release of the system shall be heat-resistant, e.g. mineral-insulated cable or equivalent. Piping systems essential for the release of systems designed to be operated hydraulically or pneumatically shall be of steel.

2.4.2.7 Not more than two discharge nozzles shall be fitted to any container.

2.4.2.8 The containers shall be monitored for decrease in pressure due to leakage or discharge. Visual and audible alarms in the protected space and on the navigating bridge/central control stand shall be provided to indicate this.

2.4.2.9 Each container is to be fitted with an over-pressure release device which under the action of fire causes the contents of the container to be automatically discharged into the protected space.

2.5 Piping and nozzles

2.5.1 Pipe materials and wall thickness have to be selected according to Section 13d.

2.5.2 Wherever possible, pipe connections are to be welded. For detachable pipe joints, flange connections are to be used. For pipes with a nominal internal diameter of less than 50 mm threaded welding sockets may be employed. Threaded joints may be used only inside protected spaces.

2.5.3 Flexible hoses may be used for the connection of containers to a manifold in centralised systems or to a rigid discharge pipe in modular systems. Hoses shall not be longer than necessary for this purpose and be type approved for the use in the intended installation. Hoses for modular systems are to be flame resistant.

2.5.4 Only nozzles approved for use with the system shall be installed. The arrangement of nozzles shall comply with the parameters specified in the system's type approval Certificate, giving due consideration to obstructions. In the vicinity of passages and stairways nozzles shall be arranged such as to avoid personnel being endangered by the discharging gas.

2.5.5 The piping system shall be designed to meet the requirements stipulated in 2.1.5.

2.5.6 In piping sections where valve arrangements introduce sections of closed piping (manifolds with distribution valves), such sections shall be fitted with a pressure relief valve and the outlet of the valve shall be led to the open deck.

2.6 Release arrangements and alarms

2.6.1 The system is to be designed for manual release only. The controls for the release are to be arranged in lockable cabinets (release stations), the key being kept conspicuously next to the release station in a locked case with a glass panel. Separate release stations are to be provided for each space which can be flooded separately. The release stations shall be arranged near to the entrance of the protected space and shall be readily accessible also in case of a fire in the related space. Release stations shall be marked with the name of the space they are serving.

2.6.2 Centralised systems shall be provided with additional means of releasing the system from the storage space.

2.6.3 If the protected space is provided with a system containing a halocarbon clean agent as fire extinguishing agent, the mechanical ventilation of the protected space is to be stopped automatically before the discharge of the extinguishing gas.
2.6.4 Audible and visual alarms shall be provided in the protected space and additional visual alarms at each access to the space.

2.6.5 The alarm shall be actuated automatically by opening of the release station door. For installations with a design concentration in excess of the NOAEL, see 2.1.3, means shall be provided to safeguard that the discharge of extinguishing gas is not possible before the alarm has been actuated for a period of time necessary to evacuate the space but not less than 20 s.

2.6.6 Audible alarms shall be of horn or siren sound and be clearly distinguishable from other audible signals.

2.6.7 Electrical alarm systems shall have power supply from the main and emergency source of power.

2.6.8 For the use of electrical alarm systems in gas dangerous zones refer to Chapter 6 – Electrical Installations.

2.6.9 Where pneumatically operated alarms are used the permanent supply of compressed air is to be safeguarded by suitable arrangements.

2.7 Tightness of the protected space

2.7.1 Apart from being provided with means of closing all ventilation openings and other openings in the boundaries of the protected space, special consideration shall be given to 2.7.2 through 2.7.4.

2.7.2 A minimum agent holding time of 15 min shall be provided.

2.7.3 The release of the system may produce significant over- or under-pressurisation in the protected space which may necessitate the provision of suitable pressure equalising arrangements.

2.7.4 Escape routes which may be exposed to leakage from the protected space shall not be rendered hazardous during or after the discharge of the extinguishing gas. Control stations and other locations that require manning during a fire situation shall have provisions to keep HF and HCl below 5 ppm at that location. The concentrations of other products shall be kept below values considered hazardous for the required duration of exposure.

2.8 Warning signs and operating instructions

2.8.1 Warning signs are to be provided at each access to and within a protected space as appropriate:
- "WARNING! This space is protected by a fixed gas fire extinguishing system using ......... . Do not enter when the alarm is actuated!"
- "WARNING! Evacuate immediately upon sounding of the alarm of the gas fire extinguishing system."

2.8.2 Brief operating instructions are to be posted at the release stations.

2.8.3 A comprehensive manual with the description of the system and maintenance instructions is to be provided. The manual shall contain an advice that any modifications to the protected space that alter the net volume of the space will render the approval for the individual installation invalid. In this case amended drawings and calculations have to be submitted to GL for approval.

2.9 Documents

Prior to commencing of the installation the following documents are to be submitted in triplicate to GL Head Office for approval:
- arrangement drawing of the protected space showing machinery, etc. in the space, and the location of nozzles, containers (modular system only) and release lines as applicable
- list of volumes deducted from the gross volume
- calculation of the net volume of the space and required supply of extinguishing gas
- isometrics and discharge calculations
- release schematic
- drawing of the release station and of the arrangement in the installation/unit
- release instructions for display at the release station
- drawing of storage space (centralised systems only)
- alarm system schematic
- parts list
- manual on board of unit or on installation

2.10 Testing

2.10.1 Piping up to a shut-off valve if available is subject to hydrostatic testing at 1.5 times the maximum allowable working pressure of the gas container.

2.10.2 Piping between the shut-off valve or the container valve and the nozzles is subject to hydrostatic testing at 1.5 times the maximum pressure assessed by the discharge calculations.

2.10.3 Piping passing through spaces other than the protected space is subject to tightness testing after installation at 10 bar, and at 50 bar if passing through accommodation spaces.

G. Steam Fire Extinguishing Systems

1. Steam may be used as extinguishant in limited local applications if agreed upon with GL.

2. Reference is made to the International Code of Fire Safety Systems (FSS Code), Chapter 5, 2.3.
H. Portable Fire Extinguishers and Fireman’s Outfit

1. Portable and mobile fire extinguishers

1.1 General

Water, dry powder, CO₂ or foam should be used as extinguishing agents for the portable and mobile fire extinguishers to be provided in accordance with Table 10.3.

Portable extinguishers shall on principle also be suitable for fighting fires in electrical installations.

Water extinguishers may be used in accommodation spaces.

1.2 Capacity

1.2.1 The capacity is limited by the following requirements:

- the capacity of required portable fluid extinguishers is to be not more than 13.5 litres and not less than 9 litres
- the weight of the charge in dry powder and gas filled portable extinguishers shall be at least 5 kg
- the total weight of a portable extinguisher ready for use shall not exceed 23 kg
- mobile extinguishers shall be designed for a standard dry powder charge of 50 kg or for a foam solution content of 45 or 135 litres

1.2.2 Spare charges are to be provided for each portable extinguisher capable of being recharged.

One spare extinguisher is to be provided for each portable extinguisher which cannot be recharged on the installation/unit.

1.3 Location

1.3.1 With regard to the number prescribed in Table 10.3 and the recommendations for the location of portable and mobile extinguishers, the following has to be observed:

a) at least one portable extinguisher has to be located in every division enclosed by fire bulkheads;

b) one of the portable extinguishers to be provided in any space has to be located at the access to such space;

c) for small spaces the number of portable extinguishers may be reduced;

d) portable CO₂ extinguishers may not be located in accommodation spaces.

1.3.2 For exterior locations in hazardous zones 1 and 2, compare Section 2, the distance between individual portable powder extinguishers shall not be more than 15 m. In addition, at least two portable CO₂ extinguishers have to be provided in the vicinity of electrical installations.

1.3.3 For the accommodation area, the distance between extinguishers shall not be more than 20 m, and at least one extinguisher shall be provided on each level.

2. Fireman’s outfits

2.1 Type of outfit

Each fireman’s outfit shall consist of at least:

a) breathing apparatus of an approved type which may be either:

- a smoke helmet or smoke mask which shall be provided with a suitable air pump and a length of air hose sufficient to reach from the open deck, well clear of doorway to any part of the machinery spaces. If, in order to comply with these Rules, an air hose exceeding 36 m in length would be necessary, a self-contained breathing apparatus shall be substituted or provided in addition as determined by GL, or

- a self-contained compressed-air-operated breathing apparatus, the volume of air contained in the cylinders of which shall be at least 1200 l, or other self-contained breathing apparatus which shall be capable of functioning for at least 30 minutes.

At least two spare fillings have to be provided for each breathing apparatus.

b) a fire proof lifeline of sufficient length and strength, capable of being attached by means of a snap hook to the harness of the breathing apparatus or to a separate belt in order to prevent the breathing apparatus becoming detached when the lifeline is operated;

c) protective clothing of material to protect the skin from the heat radiating from the fire and from burns and scalding by steam. The outer surface shall be water resistant;

d) boots and gloves of rubber or other electrically non-conducting material;

e) a rigid helmet providing effective protection against impact;

f) an electric safety lamp (hand lantern) of approved type with a capacity for at least three hours;

g) an axe with high-voltage insulation to the satisfaction of GL.

2.2 Number

At least two fireman’s outfits shall be provided.

2.3 Storage

The fireman’s outfits have to be stored in a safe area, readily accessible and ready for use, in at least two locations as far apart from each other as practicable.
2.4 Communication

For internal communication one portable UHF radio set for each set of fireman’s equipment, for the fire fighting supervisor, the technical supervisor and the safety control centre are to be provided.

I. Arrangements in Machinery Spaces and Spaces Containing Fired Processes

1. Extinguishing equipment

1.1 Spaces containing internal combustion machinery with a total power output of not less than 750 kW, oil or gas fired boilers, heaters or incinerators of not less than 75 kW thermal rating, or spaces containing oil fuel units or settling tanks, shall be provided with one of the following fixed fire fighting systems:
   - a pressure water spraying system
   - a CO₂ system or a system using an extinguishing gas other than CO₂
   - a high expansion foam system

1.2 Spaces containing internal combustion machinery with a total power output of not less than 750 kW are, in addition, to be furnished with one mobile foam type extinguisher of not less than 45 litres capacity or equivalent and one approved portable foam extinguisher or equivalent for each 750 kW of engine power output or part thereof. The total number of portable extinguishers shall not be less than 2 and need not exceed 6.

1.3 Spaces containing oil or gas fired boilers or equivalent shall be furnished, in addition, with at least two approved portable foam extinguishers or equivalent in each space containing a fired process installation or part of the oil fuel installation, and at least one extinguisher of the same description with a capacity of 9 l for each burner, provided that the total capacity of the additional extinguishers need not exceed 45 litres for each space.

2. Stopping of ventilating fans and pumps

2.1 Means are to be provided for stopping ventilating fans serving machinery and working spaces, and for closing all doorways, ventilators, annular spaces around funnels and other openings to such spaces. These means are to be capable of being operated from outside such spaces in case of fire.

2.2 Machinery driving forced and induced draught fans, electric motor pressurization fans, oil fuel transfer pumps, oil fuel unit pumps and other similar fuel pumps are to be fitted with remote controls situated outside the space concerned, so that they may be stopped in the event of a fire arising in the space in which they are located.

3. Fuel oil shut-off valves

Every oil fuel suction pipe from a storage, settling or daily service tank is to be fitted with a cock or valve capable of being closed from outside the space concerned in the event of a fire occurring in the space in which such tanks are situated. In the special case of deep tanks situated in any shaft tunnel (self-propelled units) or pipe tunnel, valves on the tanks are to be fitted, but control in the event of fire may be effected by means of an additional valve on the pipeline or lines outside the tunnel or tunnels.

J. Control Stations, Fire and Gas Detection Systems

1. Control stations

1.1 Arrangement

At least one control station, which is to be permanently manned, shall be provided in the safe area. Depending on the design of the offshore installation or unit, a second control station may be required. The arrangement of the control station(s) is to be determined from case to case.

1.2 Equipment

In the control station with the central fire and gas alarm consoles the following items shall be provided:

a) Means of communication between the stations essential to the safety of the installation/unit;

b) all the necessary arrangements for the emergency shut-off and remote controlled valves referred to in I.2., I.3. and in Chapter 6 – Electrical Installations;

c) arrangements for starting the fire pumps referred to in D.1.1.8;

d) manual means to set off the general, fire and gas alarms;

e) means of indicating whether fire doors are closed and whether the bulkhead doors are open or closed;

f) the fire alarm and gas alarm central consoles, lists and location plans/tables of fire detectors and gas monitoring points, and the control plans;

g) the electric and electronic equipment as defined in Chapter 6, Section 9, C.

2. Fire detection and alarm system

2.1 General

Every offshore installation/unit shall be provided with an automatic fire detection system for all accommodation and service spaces. Sleeping quarters shall be fitted with smoke detectors. All systems or equipment

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7 Water mist systems which are type approved in accordance with MSC/Circ. 1165 may be used. (Approvals acc. to MSC/Circ. 668/728 remain valid until 10 June 2010.)
installed on mobile offshore units shall comply with the International Code for Fire Safety Systems, Chapter 9. See also Chapter 6 – Electrical Installations, Section 9, C.

2.2 Manual alarm
Sufficient manual fire alarm stations shall be fitted at suitable locations throughout the installation/unit.

2.3 Hazardous areas
In the hazardous areas referred to in Section 2 only alarm loops of a certified safe type may be used.

2.4 Arrangement of detectors and alarm loops
2.4.1 Every alarm loop shall not cover more than one fire zone or watertight compartment and, as far as practicable, not more than one deck or a stairway connecting more than two decks.

Where there are arrangements for the separate flooding with fire extinguishing media of two or more adjoining spaces, separate alarm loops have also to be provided.

2.4.2 For areas provided with automatic pressure water spray systems, separate alarm loops per section are to be allocated.

2.4.3 The number of the detectors shall not exceed 20 per alarm loop.
Manually actuated alarms may be incorporated in a loop together with automatic alarms.

2.4.4 The arrangement and number of detectors have to be such that all hazardous areas are covered. This applies in particular to control and working spaces.

2.5 Fire detection and alarm systems for machinery spaces
2.5.1 Machinery spaces of category A of mobile offshore units with Class Notation AUT or AUT-Z are to be equipped with a fire detection and alarm system. The system shall be designed to detect smoke.

2.5.2 Spaces for emergency generators, which are used in port for serving the main source of electrical power are to be provided with a fire detection system regardless of the output of the diesel engine.

2.5.3 Exhaust gas fired thermal oil heaters are to be fitted with a fire alarm on the exhaust gas side.

3. Gas detection and alarm system
3.1 General
A fixed automatic gas detection and alarm system is to be provided. It is to be so arranged as to monitor continuously all areas where an accumulation of flammable gases may be expected to occur, and be capable of indicating at the main control station by audible and visual means the presence and location of an accumulation of gas.

3.2 Number
At least two portable gas monitoring devices are to be provided, each capable of accurately measuring a concentration of flammable gas.

3.3 Further details
For further details of the requirements for design and operation see Chapter 6 – Electrical Installations, Section 9, C.

K. Storage of Gas Bottles
Where more than one cylinder of oxygen and more than one cylinder of acetylene are carried simultaneously, such cylinders should be arranged in accordance with the following.

1. Piping
Permanent piping systems for oxyacetylene systems are acceptable provided that they are designed having due regard to standards and codes of practice to the satisfaction of GL.

Fixed piping is to be of steel or equivalent material.

2. Closed storage
2.1 Where two or more cylinders of each gas are intended to be carried in enclosed spaces, separate dedicated storage rooms are to be provided for each gas.

2.2 Storage rooms are to be constructed of steel and be well ventilated and accessible from open deck.

2.3 Provision shall be made for the expeditious removal of cylinders in the event of fire.

2.4 "NO SMOKING" signs shall be displayed at the gas cylinder storage rooms.

3. Open storage
Where cylinders are stowed in open locations, the following is to be ensured.

3.1 Cylinders and associated piping shall be protected from physical damage.

3.2 Exposure to hydrocarbons shall be minimized and suitable drainage provided.
4. Fire protection

Fire extinguishing arrangements for the protection of areas or spaces where such cylinders are stored shall be provided to the satisfaction of GL, compare F.1.7.

It will be considered in each case, whether or not a deluge system or a similar special protection system is required.

L. Miscellaneous

1. Fire control plan

Fire control plans complying with Regulation 15.2.4 of Chapter II-2 of the 1974 SOLAS Convention, as amended are to be permanently exhibited in prominent places. Plans according to the standard ISO 17631 are recommended.

2. Availability

Fire extinguishing appliances shall be kept in good order and be available for immediate use at all times.

3. Protection of structural members

Consideration is to be given to the passive or active protection of primary structural members or other structural items, which may cause the collapse of the structure or impede the evacuation of the crew in cases of extended hydrocarbon fires.

4. Shore connection

Mobile offshore units shall be provided with at least one international shore connection complying with the International Code for Fire Safety Systems, Chapter 2. Compare also Fig. 10.1.

It shall be possible to use the shore connection on either side of the unit.

5. Helicopter facilities

The fire protection and fire extinguishing systems for helicopter decks and refuelling capabilities are defined in Chapter 4, Section 9, D.

Fig. 10.1 International shore connection
Section 11

Drilling, Workover, Production systems and Process Systems

A. General

1. Scope
This Section applies to systems for drilling, work-over and for the production of hydrocarbons on fixed offshore installations and floating units.

2. Reference to other rules, regulations and standards
Designs based on other internationally recognized rules, regulations or standards, e.g. API, will be accepted if they provide an equal degree of safety. Attention is drawn also to governmental regulations and/or requirements imposed by local authorities.

3. For safety systems, see also Section 17.

B. Design and Installation

1. Arrangement of drilling systems

1.1 The arrangement of drilling derricks and rotary equipment requires consideration of the drilling task. It has to be ensured that, when shifting the drilling system to any of the well locations predetermined by the substructure, the safety of other systems on the installation/unit is not affected.

1.2 Other components of the drilling system have to be placed or protected so that in case of hazardous situations their function is maintained as long as possible.

Sufficient space for mobile auxiliary equipment has to be available.

Protection and ventilation of operation areas have to be suitable to initiate immediate emergency action.

If housings or areas need additional sheltering, these have to be of sufficiently strong and fire resistant design. By their arrangement remedial action by personnel in case of emergencies shall not be impeded.

1.3 Systems for transfer of loads and embarkation of personnel shall remain operable, to the greatest possible extent, even in hazardous situations.

1.4 The individual components of machinery and facilities for drilling or workover systems are covered in detail also by other Chapters/Sections. Drilling rigs and equipment shall comply with recognized standards and recommended practices for such equipment.

1.5 For area classification see Section 2 and 2. in the following.

2. Arrangement of production, process and transportation facilities and machinery

2.1 The arrangement of such facilities and machinery is generally subject to the process requirements. A variety of safety aspects has to be considered, some of which are listed in the following.

2.2 Area classification requirements
Area classification requirements shall be observed for the following items:

- boilers, fired equipment, internal combustion engines, compressors and all other equipment constituting a source of ignition shall normally not be located in hazardous areas
- separation of oil treatment from gas treatment facilities
- means of isolation of systems for sour service from those for non-sour service
- separation of high and low pressure systems if practicable
- separation of production systems from auxiliary/utility systems
- requirements for maintenance and lay-down areas if units need disassembling

2.3 Exemptions from area classification requirements

2.3.1 If it is unavoidable to place machinery or equipment, which may cause ignition, in areas designated as hazardous, pressurized compartments have to be provided meeting the following minimum requirements:

- The pressurization shall be so arranged as to maintain a positive pressure even with one door fully open.
- Self-closing doors have to be provided in combination with an air lock system.
Air intake openings and combustion air inlets have to be located in safe areas. Inlet ducts shall be kept clear of hazardous areas as far as practicable.

Combustion air inlets shall be provided with approved flame arrestor devices as close as practicable to inlet ports of engines.

Gas detectors shall be fitted at the entry to air inlet ducts and initiate an audible and visual alarm if the gas concentration reaches 20 % LEL (Lower Explosive Limit).

In case gas concentrations reach 60 % LEL or the air pressurization cannot be maintained, an audible and visual alarm shall be activated and machinery as well as fuel supply shall be stopped automatically.

Internal combustion engines shall be provided with automatically operating devices preventing explosion or overspeeding in case of gas ingress into combustion air ducts.

Exhaust openings shall be led to safe areas. Efficient spark arrestors and flame traps shall be fitted in addition.

2.3.2 If it is unavoidable to place internal combustion engines in hazardous areas without the provision of a pressurized compartment, the installation has to comply with the requirements of Section 2, D.1.

2.3.3 If it is unavoidable to place compressors in hazardous areas, the air inlets shall be ducted from safe areas. Gas detectors shall be fitted at the air entry. In the event of gas ingress, a visual and audible alarm shall be activated and compressors shut down automatically.

2.4 Machinery operating on process gas

The use of process gas as fuel has to be especially agreed upon with GL.

As far as applicable the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 6 - Liquefied Gas Tankers have to be complied with.

3. Documents for review and approval

The following documents and plans containing all relevant data regarding operation and safety requirements shall be submitted in triplicate:

- general arrangement plans of the entire drilling and/or production system showing the locations of the different permanently installed facilities, machinery and equipment as well as spaces for temporarily used service contractor equipment
- drawings showing the location of accommodations and any other spaces where people may be staying (e.g., control stations) in relation to the drilling and production facilities
- documentation and schematic diagrams (flow sheets) explaining the purpose, process and operation of individual units including contractor equipment
- detailed documents and plans explaining the purpose and operation of auxiliary equipment or supporting systems as well as explaining the dependability of the main systems on safe and reliable functioning of such auxiliary systems
- documents highlighting specific risks of operation or process as well as their prevention, e.g., blowouts, presence of H₂S, reactions of chemicals used, etc.
- analyses of oil, gas, reservoir waters expected or discovered
- requirements from any legal (Administration) clean air or clean water acts
- documents and plans stipulating maximal/minimal pressure ratings or maximal capacities or loads
- philosophy and arrangement of drilling and/or production safety systems, including blow out prevention and ESD systems as well as proposed emergency measures
- arrangement and function of emergency vent and flare systems (see also Section 14)
- plans explaining area classification and ventilation systems
- plans showing escape and embarkation routes and means for personnel protection in emergency situations. Safe areas have to be determined according to the prevailing wind direction
- arrangement, construction and operating plans for facilities or equipment which are not covered by individual Sections of these Rules, yet have an essential impact on the safety of human life or the installations; such documents and plans have to be presented in detail
- detailed information on selection of materials, welding, testing, etc. for manufactured components
C. Design and Installation of Piping Systems

1. Design principles

1.1 General

The design, construction and installation of piping related to systems as specified in B.1. and B.2. have to be in accordance with Section 13b – 13e.

At the design or construction stage provision shall be made for the assessment of abrasion/corrosion/erosion in piping and equipment throughout the lifetime of the systems. Measurement points shall be stipulated at critical sections subject to material loss. Zero readings at start up and comparative readings during periodical checks shall be taken.

1.2 Drilling and workover units

1.2.1 For the design of piping systems on drilling and workover units the following influence factors have to be considered.

1.2.2 Vibrations and pulsations

Vibrations and pulsations due to the operation of reciprocating mud pumps (piston type, plunger type) shall be compensated by the following measures:

- provision of special fixations, clamps, flexible long radius bends, etc. to absorb vibrations
- installation of pulsation dampeners
- use of all steel flexible lines (e.g. chicksan type)
- use of rotary vibrator hoses as flexible connectors between mud pump manifold and standpipe
- use of rotary (drilling) hose or mud hose as flexible connector between top of standpipe and rotary swivel
- hoses have to be in compliance with an recognized standard
- materials used for hoses and sealing elements have to be resistant to hydrocarbons, its compounds, chemicals, acids and hydrogen sulphide; appropriate pressure and temperature ratings have to be observed

1.2.3 Abrasion and erosion

Due to colloidal suspended additives in drilling muds (clays, barytes, even fine coarse sand) mud streams are extremely abrasive. Preventive measures are required as follows, e.g.:

- increased wall thickness
- hardened pipe surfaces
- use of hard metal platings
- avoidance of small radius bows

- use of exchangeable, long radius bows (goose-necks)
- use of tungsten carbide materials in valves, chokes and sharp bends

These provisions shall apply particularly to circulation lines, kill and choke lines as well as to all manifolds.

1.2.4 Corrosion

Corrosive wear may occur due to the effects of the marine environment as well as due to the corrosive nature of liquids or gases handled. Preventive measures are required as follows, e.g.:

- selection of resistant materials
- surface protection
- coating of inner or outer surfaces
- use of inserted plastic pipes
- application of chemical inhibitors
- use of plastic pipes (in low pressure systems only)

1.2.5 Effect of temperature changes

Temperature changes due to gas expansion or pre-heating have to be considered mainly for:

- stand pipes
- kill and choke lines
- choke manifolds
- vent and flare lines

Insulation of the piping systems has to be considered in winter or arctic services. The provision of heat tracing may be necessary for:

- mud circulation lines
- control lines
- regulators, governors including piping

1.3 Wellhead and process platforms

1.3.1 For the design of piping systems on wellhead and process platforms the following influence factors have to be considered.

1.3.2 Maximal pressure ratings

Sections of different pressure ratings in piping systems have to be separated by pressure control devices, safety shut-off valves and pressure relief devices. Relief devices have to be installed at locations and provided with means which prevent isolation from the system to be protected. They have to be accessible for operational inspection and maintenance.
1.3.3 Corrosion and erosion
Corrosive wear is to be anticipated due to the effect of the marine environment as well as due to the corrosive nature of liquids or gases produced. Erosive wear has to be anticipated in systems for high velocity and from particles carried by the produced media, e.g., return drilling mud compounds, formation materials, corrosion products. Preventive measures are, for example;
- adequate pipe diameters to reduce flow velocity
- use of corrosion resistant materials; selection needs special consideration; for sour service refer to Section 15
- insertion of plastic pipes
- use of plastic pipes (in low pressure systems only)
- application of chemical inhibitors
- erosion resistant surface hardening (if not in contradiction to corrosion prevention)
- use of platings or linings
- use of tungsten carbide materials (valves, chokes, regulators)
- heat treatment for stress relieving

1.3.4 Temperature changes, heat tracing, thermal insulation
Temperature changes due to gas expansion or preheating have to be considered mainly for:
- flow lines
- specific process lines (low temperature separation)
- injection lines for hot oil injection or circulation
Thermal insulation and preheating or heat tracing has to be considered for:
- wet gas lines or high pressure produced oil lines to prevent formation of hydrates or depositing of asphaltenes or paraffins
- control lines
- regulators, governors incl. piping

1.3.5 Separation of hazardous from non-hazardous systems
1.3.5.1 Piping systems carrying non-hazardous fluids or gases shall be separated from systems containing hazardous fluids or gases to prevent uncontrolled blending. Exceptions require the consent of GL.
1.3.5.2 Where blending of non-hazardous and hazardous streams is necessary, or in systems for air or steam injection, provision has to be made to prevent contamination of piping systems carrying non-hazardous media. The point of entry of the non-hazardous medium is to be located as close as practicable to the blending device, burner or vent.

1.3.6 Fire precautions
When designing safety relief valves for pressure vessels, consideration has to be given to the additional pressure and flow developing during the vessel's engulfment in fire. Provision has to be made for the safe draining of additional flow.

2. Construction requirements
2.1 Piping shall not be installed on partitions or flooring; adequate head clearance and access for maintenance has to be provided.
2.2 The location and design of piping supports shall be according to individual circumstances, i.e. space requirement, weight, medium carried, vibrations, etc. Piping shall be supported on racks, stanchions or individual standoffs.
Valve supports shall not interfere with removal of the valve for maintenance.
2.3 Piping shall be installed with a minimum of bends. For high pressure lines such as high velocity flow lines, kill and choke lines, the mean bend radius should be 5 times the outside diameter of the pipe, for other pipes 3 times the outside diameter. In confined spaces standardized or built up bends and shapes may be used.
2.4 Reactive forces on pumps and machinery from piping shall be prevented by
- accurate alignment
- use of suitable independent supports and hangers
- means for compensation of thermal contraction/expansion
2.5 Piping shall not be laid in the vicinity of electrical switchboards, etc. If this is unavoidable, suitable protective measures have to be taken to prevent damage due to leakages.
2.6 Piping shall be suitably insulated where required for personnel protection or by process demands.
2.7 Pipes shall be clearly coded according to the medium carried following a standardized system to avoid misunderstandings during operation.

3. Pipe fittings
3.1 All fittings relating to pipe Class I have to be proven to be suitable for the intended use.
This proof may consist of a type test, but the type test does not replace the individual test for valves referred to in Section 13d.
All valves and fittings assigned to classes other than Class I have to comply with a recognized standard.

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1 for pipe classes see Section 13d.B.
3.2 Power drives for valves have to be of an acknowledged design.

3.3 Power driven shut-off devices have to be fitted with emergency means of actuation which are permanently ready for use.

3.4 In case of power failure, power driven shut-off devices, depending on their intended use, have to
- remain in the set position in closed pipe systems such as cooling water systems
- close automatically in open pipe systems such as bilge systems for floating offshore units
- move to a fail safe position (open or closed), as required by the process

3.5 Where safety so requires, the power supply for remote controlled shut-off devices shall be duplicated such that, if the main supply fails, the stand-by supply is activated automatically and will be fed from the installation's/unit's emergency source of power.

3.6 The position of remote controlled shut-off devices as specified in 3.2 to 3.5 shall be indicated at the control room and locally at all times.

4. Flanges

Flanges shall be designed in accordance with Section 13d, E. For protection against corrosion in marine environment flange protectors may be required.

5. Gaskets

Ring joints and gaskets shall be of appropriate design and material for the medium carried and in accordance with a recognized standard.

Consideration shall be given to conditions (pressures, temperatures) prevailing during normal operation and in emergency situations.

6. Bolts

6.1 Bolts used for flange connections have to be designed in accordance with recognized standards. For protection of bolts from marine environment insulation or flange protectors may be required.

Bolts used for piping in hydrocarbon systems shall be stud bolts in accordance with ASTM standards.

6.1 If bolting is used in sour service, particularly where insulation or flange protectors are provided, the direct exposure of the bolts to sour gas may still not be sufficiently prevented. In such cases the application of Section 6, NACE MR 01-75, is mandatory for the selection of bolt materials. The use of lower strength materials may require a change in flange design.

7. Flexible hoses

Where flexible hoses are to be used, their design, manufacture and testing shall be in accordance with a recognized standard or code of practice. Attention is drawn in particular to the testing for dynamic loads and fire resistance.

D. Drilling Safety System

1. General

1.1 For the safe drilling and completing of a well a drilling safety system shall be provided. Depending upon the drilling programme, it shall incorporate a diverter and/or a blow-out preventer together with all the auxiliary appliances and equipment required to operate the system.

1.2 The purpose of the drilling safety system is to confine any fluids, mainly muds, pumped into the well (for return of cuttings, well stabilization and hydrostatic head), their treatment and their controlled return as well as the controlled release of reservoir fluids or gases during normal drilling and in emergency situations.

1.3 Where an offshore installation is used simultaneously for several purposes such as drilling, production and accommodation, or where the installation comprises two or more separate bridge-linked platforms or units, the safety philosophy shall be developed in accordance with the overall safety requirements for the installation/unit and shall be agreed by GL.

2. System components

2.1 The components of a safety system include, but are not limited to, the following:
- conductor pipe (part of well site equipment)
- diverter system
- blow-out preventer stack and casing spools
- preventer closing unit, control line piping and auxiliary equipment
- choke manifold
- kill, choke and bleed lines
- marine risers
- telescopic and flexible joints

2.2 All components of such systems have to be designed and manufactured in accordance with codes and standards accepted by GL. Manufactured components for pressure rated service and/or elements for sour service shall be provided with Certificates acceptable to GL. Design and construction of other components have to be in accordance with the requirements of these Rules.
2.3 Although cementing is not subject to these Rules, attention is drawn to the cementation of all casings, since it has to be seen as part of the drilling safety system. Due consideration shall therefore be given by the Operator to ensure the integrity and bond of each cementation for surface, intermediate and production casing.

2.4 Diverter system

A diverter system shall be provided for the purpose of directing overboard, downwind, unbalanced return flows from the well bore away from the classified areas of the drilling rig.

The diverter system generally consists of the extended conductor pipe, the diverter (rotating head or annular preventer) and the lateral diverter line system below. The diverter system is not required to shut in or halt the return flow.

Tie diverter line, riser pipe and vent pipe shall be of sufficiently large diameter to enable the return flow to be disposed of safely, without causing well bore back pressure.

Any valves in the diverter piping shall be of the full opening type and shall be designed for automatic opening upon closure of the diverter.

Diverter piping shall be laid as straight as possible and firmly anchored.

The use of bends and flexible hoses shall be avoided to the greatest extent practicable.

2.5 Blow-out preventer system

2.5.1 General

Depending on the drilling programme, a blow-out preventer (BOP) system shall be provided for each drilling and/or workover operation. The system, consisting of the cemented casing, spools, BOP stack, closing unit, hydraulic pumps with accumulator and all pertinent piping and valves, shall be arranged to ensure to safe shutting-in of a well.

In accordance with a recognized standard or code of practice, each system component shall be designed for the correct pressure and temperature rating and properties of the well and treatment fluids to be encountered.

2.5.2 Blow-out preventer stack

The blow-out preventer stack and casing spools shall be selected and arranged in accordance with

- the maximum expected well head pressure (standardized in pressure ratings)
- the required sizes for drill strings and casings programmed for each stage of the drilling operation.

A BOP stack shall therefore consist of three or more individual preventers, e.g.,

- one annular preventer (on top)
- one blind ram preventer to allow full well closure with no drill pipe in the hole
- one pipe ram preventer for each size of drill pipe/casing as determined by the drilling program. In such a case, in order to facilitate stripping operations, the arrangement of an adequate spool between two preventers may be recommended instead of individual ram type preventers, combinations of blind and pipe rams may be used.

2.5.3 BOP closing unit

The BOP closing unit shall be capable of being activated from the driller’s panel and additionally from at least one more panel at a remote safe location.

With the pumps inoperative, hydraulic accumulators shall have sufficient capacity for at least two closing actions (one ram type, one annular type preventer) plus the opening action of the hydraulically operated choke manifold.

Closing times shall not exceed

- for ram type preventers: 30 seconds
- for annular preventers: 45 seconds

More closing actions are required for the stripping of drill pipe into a well. Additional accumulator capacity has therefore to be considered.

2.5.4 Hydraulic pumps

Hydraulic pumps shall have sufficient capacity to close at least the annular preventer and to open the hydraulically operated choke manifold within 2 minutes with the accumulators inoperative.

The hydraulic pumps shall be capable of achieving a minimum of 14 bar above accumulator charge pressure within 2 minutes. They have to start automatically when the closing unit’s set pressure has decreased by 10 %.

2.5.5 Operating and control line piping

Operating and control line piping (hydraulic and/or pneumatic) has to be rated in accordance with Section 13b. It has to be arranged so that protection from heat (and frost, as applicable) and mechanical damage is ensured.

2.5.6 Choke manifolds

Choke manifolds together with pertinent piping and valves have to be designed according to pressure ratings, required flow and service conditions (sweet or sour well fluids). They have to be placed at protected locations, firmly anchored and allowing remote operation of their different functions. Kill, choke and bleed lines shall be permanently installed to the greatest degree possible. Means for the periodical pressure and function testing shall be provided.
2.5.7 Marine riser systems

2.5.7.1 General

The marine riser system acts as a guideway for the drill string and the returning mud flow between casing head housing, or between a bottom supported preventer stack and the drill floor on a floating unit.

Subsea drilling equipment shall be designed for the wide range of operating conditions and environments to be expected throughout its service life. Riser systems shall therefore have minimum yield strength, fatigue characteristics and wall thickness well in excess of the requirements for one particular service.

2.5.7.2 Design

The following requirements for a marine riser system and its components have to be complied with:

- The riser pipe has to be sufficient in size to allow free passage of drilling tools and strings as well as casings, hangers and pack-off units as defined in the drilling programme. The riser pipe shall have at least the same inner diameter as the preventer stack and wellhead. It has to be built up from manageable sections, their number depending on water depth.

- Specially designed riser connectors (torque controlled) shall allow safe and leak-tight fitting of each section. The connector shall prevent relative lateral, vertical or rotational movement between the connected pipe sections. It shall re-main free of plastic deformation and galling. The strength of each connector has to be greater than that of the riser pipe.

- The connector between preventer stack and riser has to be designed for remote (hydraulic) operation to allow immediate disconnection in case of emergency. The connector has to be designed to allow multiple engagements/disengagements without damage to its mechanical or sealing elements.

- A flexible joint shall be installed at the bottom of the riser system to compensate for misalignments, reduce stress concentrations and bending moments and allow for horizontal offsets between the rotary table and wellhead of approximately 10°.

- A telescopic joint shall be installed at the top of the riser system as connection to the drilling unit, allowing the compensation of the unit's heave. The stroke length of the telescopic joint has to be sufficient to compensate for the maximum expected heave of the vessel due to tidal and wave action. The sealing elements (pneumatically or hydraulically energized) shall be of sufficient strength for the duration of the drilling programme, or replace-able with the telescopic joint in service.

- A marine riser tensioning system is required, to provide for continuous positive tension on the complete marine riser system in order to compen-sate for the unit's movement, and maintain the riser system as straight as necessary for the free passage of drill strings and prevention of buckling.

- Positive riser buoyancy may become necessary in deep water drilling, in order to assist the tensioning system in keeping the riser system straight and for reduction of axial tension in the upper part of the riser. Careful consideration has to be given to the optimum solution between positive effects (reduction of stresses) and negative consequences (increase of cross-sectional area increases riser exposure to wave and current forces). Detailed proposals have to be submitted to GL for consideration.

- Kill, choke and preventer control lines have to be designed in accordance with well site preventer requirements. The lines have to be permanently fixed or clamped on the exterior of the main riser pipe. Where integral riser systems are used, ade-quate seal nipple assemblies have to be provided to allow engagement and disengagement of all attached lines together with the sealing nipple of each main riser section. Riser connection and seal nipple assemblies have to be tested before being installed.

- Flexible connections for kill and choke lines as well as control lines - necessary between riser and top or subsea installations to compensate for wave actions or temperature effects - have to be of an approved type (e.g. high pressure armoured hoses, all steel flexible lines, or expansion loops).

2.5.7.3 Dimensioning

For the dimensioning of the marine riser system and its elements the following forces have to be taken into account:

- Internal pressure according to maximum pressures of the well for kill and choke lines, and operating pressures for hydraulic control lines. The main riser pipe shall withstand at least the internal pressure expected when the diverter system is in ac- tion, also considering extreme mudweights for ex-tended riser lengths, and external pressure accord-ing to water depth and due to mud loss inside (at-mospheric inside pressure).

- Buckling of the riser pipe in case of malfunction of the riser tensioning system.

- Static and dynamic loads while running and pull-ing the blow-out preventer stack.

- Lateral forces from waves and currents.

- Cyclic forces resulting form waves and the unit's movement.

- Axial loads from riser weight or reactive forces from weight of the mud column inside the pipe as well as from the tensioner and buoyancy systems.
– Additional loads resulting from friction contact during running and pulling of drill strings.
– Anticipated bending forces during installation and operation.

2.5.7.4 Materials

Materials shall be in accordance with petroleum industry specifications and agreed by GL. A minimum yield strength between 345 and 552 N/mm² (50,000 and 80,000 psi) is recommended for normal wide range services.

E. Operations with Dangerous Gases

1. Types of gases

During the different types of work considered in this Section dangerous gases may appear. The most usual gases or gas mixtures are the following:

1.1 Hydrogen sulphide

Hydrogen sulphide has the chemical formula H₂S and is characterised by:

Attributes:
No colour, heavier than air, flammable, in mixture with air to explode, extreme corrosive with metals

Danger:
One of the most poisonous gases depending on the following concentration ranges:

– 1 ml H₂S / m³ air: odour like foul eggs, not dangerous
– up to 10 H₂S ml / m³ air: maximum permissible concentration on a working place (8 hours)
– above 10 H₂S ml / m³ air: respirator to be used!
– above 100 H₂S ml / m³ air: natural warning by odour gets lost, immediate danger for health
– above 700 H₂S ml / m³ air: immediate death

Occurrence:
Because of a weight heavier than air it may remain in lower locations, containments, etc. H₂S is soluble in water, drilling mud and processing liquids, which increases with increasing pressure. Accordingly at a depressurization of liquids containing H₂S it may escape from the liquid especially when it will be moved at a later time. Special care has to be taken during the repair of fittings and piping for H₂S.

1.2 Sulphur dioxide

Sulphur dioxide has the chemical formula SO₂ and is characterised by:

Attributes:
No colour, heavier than air, acrid odour

Danger:
Hurts mucous membranes (eyes, respiratory tract, lungs)

Occurrence:
Will be created as combustion product of media containing sulphur, e.g. at flares for sour gas or in processing sour gas.

1.3 Ammonia

Ammonia has the chemical formula NH₃ and is characterised by:

Attributes:
No colour, lighter than air, acrid odour, in mixture with air explosive, building of fog if higher quantities are evaporating.

Danger:
Hurts eyes and mucous membranes, at higher concentrations danger of suffocation.

Occurrence:
Treatment of drilling locations with sour gas, in refrigeration systems

1.4 Natural gas

Natural gas is also designated as “sweet gas” and is characterised by:

Attributes:
No colour, lighter than air, flammable, in mixture with air explosive, no smell if clean

Danger:
At high concentrations danger of suffocation because of missing oxygen

Occurrence:
Drilling activities, oil and gas production

1.5 Sour gas

For the special requirements for operation with sour gas see Section 17, C.

Attributes:
Mixture of sweet gas and hydrogen sulphide, the H₂S content in the mixture depends on the exploration location.

Danger:
See hydrogen sulphide.

Occurrence:
See hydrogen sulphide
2. Measures during operation

2.1 Before the start of any action which could endanger the crew by dangerous gases, a written work order should be established, which has to contain also the relevant safety measures. During the execution of the task always a supervisor has to be present.

Persons who are wearing a beard or who suffer on a perforation of the drumskin are not allowed to participate in this type of work.

2.2 In all areas of the installation/unit where the occurrence of dangerous gases might be possible, every crew member has to be equipped with a respirator and wear it on the body.

2.3 If gas alarm is triggered the crew members in the endangered area have to put on their respirators immediately. The endangered area shall be left at once. Only short actions, which will prevent additional danger, like closing of valves, carrying persons away, etc. are allowed. Escape direction should be the direction against the wind or transverse to it.

2.4 For rescue activities only professional independently working breathing apparatus shall be used. The rescue personnel shall be trained for all relevant situations and their health condition shall be ok at the time of action.

2.5 Casualties have to be brought into a gas free area and first aid measures have to be started at once.

3. Fire fighting

3.1 The following principle has to be considered:

\[
\text{burning gas} = \text{gas under control}
\]

It has always to be judged if a gas fire should be fought immediately or if it should remain burning until its source is empty or a closing of the gas system is possible in a safe way.

3.2 The fire fighting should concentrate at the beginning on the protection of the adjacent areas against the direct effect of the flames and on the protection of persons against gases developed by the fire (e.g. if H\textsubscript{2}S is burning SO\textsubscript{2} is developed, see 1.2).

3.3 Special requirements and equipment for fire fighting are defined in Section 10.
Section 12a

Steam Boilers

A. General

1. Scope

1.1 For the purpose of these requirements, the term "boiler" includes all closed vessels and piping systems used for

a) generating steam at a pressure above atmospheric (steam generators) or

b) raising the temperature of water above the boiling point corresponding to atmospheric pressure (hot water generators).

The term "steam generator" also includes any equipment directly connected to the aforementioned vessels or piping systems in which the steam is superheated or desuperheated, the circulating line and the casings of circulating pumps serving forced-circulation boilers.

1.2 Steam and hot water generators as defined in 1.1 are subject to the requirements set out in B. to F., or, if appropriate, in G.

Flue gas economizers are subject to the special requirements set out in H. In respect of materials, design and manufacture, the requirements specified in B., C. and D. apply as appropriate.

1.3 For hot water generators having a permissible discharge temperature of not more than 120 °C, and all systems incorporating steam or hot water generators which are heated solely by steam or hot liquids Section 12c applies for materials, design calculations and manufacturing principles. For equipment and testing G. applies.

2. Design Rules

2.1 For design and construction of boilers the following Rules are acceptable:

GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 7a

ASME Code, Section I, Rules for Construction of Power Boilers (American Society of Mechanical Engineers)

European Standards EN 12952 and EN 12953

2.2 As regards their construction and installation, steam boiler plants are also required to comply with the applicable statutory requirements and regulations of the country of registration of the unit or installation.

3. Definitions

3.1 Steam boiler walls
Steam boiler walls are the walls of the steam and water spaces located between the boiler isolating devices. The bodies of these isolating devices form part of the boiler walls.

3.2 Maximum allowable working pressure
The maximum allowable working pressure (design pressure) is the approved steam pressure in bar (gage pressure) in the saturated steam space prior to entry into the superheater. In once-through forced flow boilers, the maximum allowable working pressure is the pressure at the superheater outlet or, in the case of continuous flow boilers without a superheater, the steam pressure at the steam generator outlet.

3.3 Heating surface
The heating surface is that part of the boiler walls through which heat is supplied to the system, i.e.

a) the area \([\text{m}^2]\) measured on the side exposed to fire or exhaust gas, or

b) in the case of electrical heating, the equivalent heating surface:

\[
H = \frac{P \cdot 860}{18000} \quad \text{[m}^2]\]

\(P\) = electric power [kW]

3.4 Allowable steam output
The allowable steam output is the maximum quantity of steam [kg/hour] which can be produced continuously by the steam generator operating under the design steam conditions.

3.5 Lowest water level - highest flue

3.5.1 The highest flue is the highest point on the side of the heating surface which is in contact with the water and which is exposed to flame radiation or heated by gases which temperature exceeds 400 °C at maximum continuous power. The highest flue on water tube boilers with an upper steam drum is the top edge of the highest gravity tubes.

3.5.2 The requirements relating the highest flue do not apply to

– water tube boiler risers up to 102 mm outer diameter
3.5.3  The lowest water level must lie at least 150 mm above the highest flue.

This requirement has to be fulfilled also when the unit heels 4° to either side and heated surfaces with a set highest flue have to remain wetted even when the unit is at the static heeling angles laid down in Section 1, Table 1.2 to 1.4 where required. The height of the water level is crucial to the response of the water level limiters.

3.5.4  The heat accumulated in furnaces and other heated boiler parts may not lead to any undue lowering of the water level due to subsequent evaporation when the firing system is switched off.

The lowest water level is to be set so that the dropping time is not below 5 minutes.

3.5.5  The lowest specified water level is to be indicated permanently on the boiler shell by means of a water level pointer. Reference plates are to be attached additionally beside or behind the water level gauges pointing at the lowest water level.

3.6  Dropping time

The dropping time is the time taken by the water level, under conditions of interrupted feed and permissible steam output, to drop from the lowest water level (LWL) to the level of the highest flue:

\[ t = \frac{V}{D \cdot v'} \]

\( t \) = dropping time [min]

\( V \) = volume of water between the lowest water level and the highest flue [m³]

\( D \) = allowable steam output [kg/h]

\( v' \) = specific volume of the water at saturation temperature [m³/kg]

3.7  Manual operation

3.7.1  The facility is to be provided for manual operation. At least the water level limiters shall remain active even in manual operation.

3.7.2  Manual operation demands constant and direct supervision of the system.

3.7.3  For detailed requirements in respect of manual operation of the firing system, see Section 12d.

4.  Documents for approval

Drawings, documentation and calculations of all boiler parts subject to pressure, such as drums, headers, tubes, manholes and inspection covers, etc., are to be submitted to GL in triplicate. These drawings shall contain all the data necessary for strength calculations and design assessment, such as working pressures, superheated steam temperatures, materials to be used and full details of welds including filler materials.

Details and drawings are also to be submitted covering the valves and fittings and their arrangement, together with a description of the boiler plant specifying the arrangement of the boiler, the essential boiler data and equipment items, e.g. steam conditions, heating surfaces, allowable steam output, feed, firing system, safety valves, controllers and limiters.

B. Materials

1.  General requirements

With respect to their workability during manufacture and their characteristics in subsequent operation, materials used for the manufacture of steam boilers shall satisfy the technical requirements, particularly those relating to high-temperature strength and, where appropriate, weldability.

2.  Approved materials

The requirements specified in 1. are recognized as having been complied with materials as defined in the relevant design rules according to A.2.1.

Materials not specified in the GL Rules II – Material and Welding, Part 1 – Metallic Materials may be used, provided that proof is supplied of their suitability and mechanical properties as indicated in the relevant rules.

3.  Material testing

3.1  The materials of boiler parts subject to pressure are to be tested by GL in accordance with the GL Rules II - Materials and Welding and attested by a GL Material Certificate according to Part 1 – Metallic Materials, Chapter 1 – Principles and Test Procedures; Section 1, H. of these Rules. Material testing by GL may be waived in the following cases:

a) Small boiler parts made of unalloyed steels, such as stay bolts, stays of \( \leq 100 \) mm diameter, reinforcing plates, handhole and manhole covers, forged flanges and nozzles up to DN 150 (nominal inside diameter 150 mm)

b) Smoke tubes (tubes subject to external pressure).
Table 12a.1 Testing of materials for valves and fittings

<table>
<thead>
<tr>
<th>Type of material 1</th>
<th>Service temperature [°C]</th>
<th>Testing required for:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PB ⋅ DN &gt; 2500 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DN &gt; 32</td>
</tr>
<tr>
<td>Steel, cast steel</td>
<td>&gt; 300</td>
<td></td>
</tr>
<tr>
<td>Steel, cast steel, nodular cast iron</td>
<td>≤ 300</td>
<td></td>
</tr>
<tr>
<td>Copper alloys</td>
<td>≤ 225</td>
<td>PB ⋅ DN &gt; 1500 2</td>
</tr>
</tbody>
</table>

1 No tests are required for grey cast iron.
2 Testing may be dispensed with if the nominal DN > 32 mm.

For the parts mentioned in a) and b), the properties of the materials are to be attested by Inspection Certificates in accordance with EN 10204-3.1 issued by the material manufacturer.

3.2 Special agreements may be made regarding the testing of unalloyed steels to recognized standards.

3.3 The materials of valves and fittings shall be tested by GL in accordance with the data specified in Table 12a.1.

3.4 Parts not subject to material testing, such as external supports, lifting brackets, pedestals, etc., shall be made of materials suitable for the intended purpose and in accordance with accepted engineering practice.

C. Principles Applicable to Manufacture

1. Manufacturing processes applied to boiler materials

Materials are to be checked for defects during the manufacturing process. Care is to be taken to ensure that different materials cannot be mixed up. During the course of manufacture care is likewise required to ensure that marks and inspection stamps on the materials remain intact or are transferred in accordance with the regulations.

Boiler parts whose micro structure has been adversely affected by hot or cold forming are to be subjected to heat treatment and necessary testing in accordance with the GL Rules II – Material and Welding, Part 3 – Welding, Chapter 3 – Welding in the Various Fields of Application, Section 2.

2. Welding

2.1 Boilers are manufactured by welding. The execution of welds, the approval of welding shops and the qualification testing of welders are to be in accordance with the GL Rules II – Material and Welding, Part 3 – Welding, Chapter 3 – Welding in the Various Fields of Application, Section 2.

3. Tube expansion

Tube holes shall be carefully drilled and deburred. Sharp edges are to be chamfered. Tube holes should be as close as possible to the radial direction, particularly in the case of small wall thicknesses.

Tube ends to be expanded are to be cleaned and checked for size and possible defects. Where necessary, tube ends are to be annealed before being expanded.

Smoke tubes with welded connection between tube and tube plate at the entry of the second path shall be roller expanded before and after welding.

4. Stays, stay tubes and stays bolts

4.1 Stays, stay tubes and stay bolts are to be arranged that they are not subjected to undue bending or shear forces.

Stress concentrations at changes in cross-section in threads and at welds are to be minimized by suitable component geometry.

4.2 Stays and stay bolts are to be welded by full penetration preferably. Any vibrational stresses are to be considered for long stays.

4.3 Stays are to be drilled at both ends in such a way that the holes extend at least 25 mm into the water or steam space. Where the ends have been upset, the continuous shank shall be drilled to a distance of at least 25 mm.
4.4 The angle made by gusset stays and the longitudinal axis of the boiler shall not exceed 30°. Stress concentrations at the welds of gusset stays are to be minimized by suitable component geometry. Welds are to be executed as full penetration welds. In fire-tube boilers, gusset stays are to be located at least 200 mm from the firetube.

4.5 Where flat surfaces exposed to flames are stiffened by stay bolts, the distance between centres of the said bolts shall not exceed 200 mm.

5. Stiffeners, straps and lifting eyes

5.1 Where flat end surfaces are stiffened by profile sections or ribs, the latter shall transmit their load directly (i.e. without welded-on straps) to the boiler shell.

5.2 Doubling plates may not be fitted at pressure parts subject to flame radiation.

Where necessary to protect the wall of the boiler, strengthening plates are to be fitted below supports and lifting brackets.

6. Welding of flat unrimmed ends to boiler shells

Flat unrimmed ends (disc ends) on shell boilers are only permitted as socket-welded ends with a shell projection of $\geq 15$ mm. The end/shell wall thickness ratio $s_B / s_M$ shall not be greater than 1.8. The end is to be welded to the shell with a full penetration weld.

7. Nozzles and flanges

Nozzles and flanges are to be of rugged design and properly welded to the shell. The wall thickness of nozzles shall be sufficient to safely withstand additional external loads. The wall thickness of welded-in nozzles shall be appropriate to the wall thickness of the part into which they are welded. Welding-neck flanges are to be made of forged material with favourable grain orientation.

8. Cleaning and inspection openings, cutouts and covers

8.1 Steam boilers are to be provided with openings through which the space inside can be cleaned and inspected. Especially critical and high-stressed welds, parts subjected to flame radiation and areas of varying water level shall be sufficiently accessible to inspection. Boiler shells with an inside diameter of more than 1200 mm and those measuring over 800 mm in diameter and 2000 mm in length are to be provided with means for access. Parts inside drums must not obstruct inner inspection or must be capable of being removed.

8.2 Inspection and access openings are required to have the following minimum dimensions:

- Manholes: $300 \times 400$ mm or 400 mm diameter where the annular height is $> 150$ mm, the opening is to measure $320 \times 420$

- Headholes: $220 \times 320$ mm or $320$ mm diameter

- Handholes: $87 \times 103$ mm

Sight holes are required to have a diameter of at least 50 mm; they should, however, be provided only when the design of the equipment makes a handhole impracticable.

8.3 The edges of manholes and other openings, e.g. for domes, are to be effectively reinforced if the plate has been unacceptably weakened by the cutouts. The edges of openings closed with covers are to be reinforced by flanging or by welding on edge-stiffeners if it is likely that the tightening of the crossbars, etc. would otherwise cause undue distortion of the opening.

8.4 Cover plates, manhole frames and cross-bars must be made of ductile material (not grey or malleable cast iron). Grey cast iron (at least GG-20) may be used for handhole cover crossbars of headers and sectional headers, provided that the crossbars are not located in the heating gas flow. Unless metal packings are used, cover plates are to be provided on the external side with a rim or spigot to prevent the packing from being forced out. The gap between this rim or spigot and the edge of the opening is to be uniform round the periphery and may not exceed 2 mm for boilers with a working pressure of less than 32 bar, or 1 mm where the pressure is 32 bar or over. The height of the rim or spigot shall be at least 5 mm greater than the thickness of the packing.

8.5 Only continuous rings may be used as packing. The materials used must be suitable for the given operating conditions.

D. Design Calculations

1. Design principles

1.1 Range of applicability of design formulae

1.1.1 The strength calculations represent the minimum requirements for normal operating conditions with mainly static loading. Separate allowance has to be made for additional forces and moments of significant magnitude.
1.1.2 The formulae for calculation of the wall thicknesses are to be taken from the relevant Chapters of the following rules:

- GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 7a and 8
- ASME Code, Section I
- EN 12952 and EN 12953

Independently of the applied rules, the following paragraphs are to be observed.

1.1.3 The wall thickness arrived at by applying the formulae are the minima required. The undersize tolerances permitted by the relevant rules are to be added to the calculated values. The greater local undersize tolerances for tubes need not be considered.

1.2 Design pressure $p_c$

1.2.1 The design pressure is to be at least the maximum allowable working pressure. Additional allowance is to be made for static pressures of more than 0.5 bar.

1.2.2 In designing once-through forced flow boilers, the pressure to be applied is the maximum allowable working pressure anticipated in each individual boiler sections at maximum continuous load and at set point of the safety equipment.

1.2.3 The design pressure applicable to the superheated steam lines from the boiler is the maximum allowable working pressure which safety valves prevent from being exceeded.

1.2.4 In the case of boiler parts which are subject in operation to both internal and external pressure, e.g. attemperators in boiler drums, the design may be based on the differential pressures, provided that it is certain that in service both pressures will invariably occur simultaneously. However, the design is also required to take account of the loads imposed during the hydrostatic pressure test.

1.3 Design temperature $t$

Strength calculations are based on the temperature at the centre of the wall thickness of the component in question. The design temperature is made up of the reference temperature and a temperature allowance in accordance with Table 12a.2. The minimum value is to be taken as 250 °C.

1.4 Allowable stress

The design of structural components is to be based on the allowable stress $\sigma_{zul}$ [N/mm²]. They are to be determined in accordance with the relevant rules but shall not exceed the minimum values resulting from the following relations:

1.4.1 Rolled and forged steels

For design temperatures up to 350 °C:

$$R_{m,20}^{\circ R} \over 2,7 = \text{guaranteed minimum tensile strength at room temperature [N/mm²]}$$

$$R_{eH,t}^{1,6} = \text{guaranteed yield point or minimum 0.2 % proof stress at design temperature t [N/mm²]}$$

For design temperatures over 350 °C:

$$R_{m,100000,t}^{1,5} = \text{mean 100.000 hour creep strength at design temperature t [N/mm²]}$$

### Table 12a.2 Design temperatures

<table>
<thead>
<tr>
<th>Reference temperature</th>
<th>Allowance to be added</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unheated parts</td>
</tr>
<tr>
<td></td>
<td>Heated parts heated mainly by</td>
</tr>
<tr>
<td></td>
<td>contact</td>
</tr>
<tr>
<td>Saturation temperature at max. allowable working pressure</td>
<td>0 °C</td>
</tr>
<tr>
<td>Superheated steam temperature</td>
<td>15 °C</td>
</tr>
</tbody>
</table>

1 The temperature allowable may be reduced to 7 °C provided that special measures are taken to ensure that the design temperature cannot be exceeded.
1.4.2 Cast materials

a) Cast steel: \( \frac{R_{m,20}}{32} ; \frac{R_{eH,t}}{2} ; \frac{R_{m,100000,t}}{20} \)

b) Nodular cast iron: \( \frac{R_{m,20}}{4.8} ; \frac{R_{eH,t}}{3.0} \)

c) Grey cast iron: \( \frac{R_{m,20}}{11} \)

1.4.3 Special arrangements may be agreed for high-ductility austenitic steels.

1.4.4 In the case of cylinder shells with cutouts and in contact with water, a nominal stress of 170 N/mm² shall not be exceeded in view of the protective magnetite layer.

1.4.5 Mechanical characteristics are to be taken from the GL Rules II - Materials and Welding, Part 1 – Metallic Materials or from the standards specified therein.

1.5 Allowance for corrosion and wear

The minimum allowance for corrosion and wear is \( c = 1 \) mm. For plate thicknesses of 30 mm and over and for stainless materials, this allowance may be dispensed with.

1.6 Special cases

Where boiler parts cannot be designed in accordance with the requirements or general engineering principles, the dimensions in each individual case shall be determined by tests, e.g. by strain measurements.

E. Equipment and Installation

1. General

1.1 The following requirements apply to steam boilers which are not constantly and directly monitored during operation. Note is also to be taken of statutory requirements, where appropriate.

1.2 In the case of steam boilers which are monitored constantly and directly during operation, some easing of the following requirements may be permitted, while maintaining the operational safety of the unit or installation.

1.3 In the case of steam boilers which have a maximum water volume of 150 litres, a maximum allowable working pressure of 10 bar and where the product of water volume and maximum allowable water pressure is less than 500 [bar \cdot litres], an easing of the following requirements may be permitted.

2. Safety valves

2.1 Any steam boiler which has its own steam space is to be equipped with at least two reliable, spring-loaded safety valves. At least one safety valve is to be set to respond if the maximum allowable working pressure is exceeded.

In combination, the safety valves shall be capable of discharging the maximum quantity of steam which can be produced by the steam boiler during continuous operation without the maximum allowable working pressure being exceeded by more than 10%.

2.2 Any steam boiler which has a shut-off but which does not have its own steam space is to have at least one reliable, spring-loaded safety valve fitted at its outlet. At least one safety valve is to be set to respond if the maximum allowable working pressure is exceeded. The safety valve or safety valves are to be designed so that the maximum quantity of steam which can be produced by the steam boiler during continuous operation can be discharged without the maximum allowable working pressure being exceeded by more than 10%.

2.3 External steam drums are to be fitted with at least two reliable, spring-loaded safety valves. At least one safety valve is to be set to respond if the allowable working pressure is exceeded. In combination, the safety valves shall be capable of discharging the maximum quantity of steam which can be produced in continuous operation by all connected steam generators without the maximum allowable working pressure of the steam drum being exceeded by more than 10%.

2.4 The closing pressure of the safety valves shall be not more than 10% below the response pressure.

2.5 The minimum flow diameter of the safety valves must be at least 15 mm.

2.6 Servo-controlled safety valves are permitted wherever they are reliably operated without any external energy source.

2.7 The safety valves are to be fitted to the saturated steam part or, in the case of steam boilers which do not have their own steam space, to the steam-water outlet of the boiler.

2.8 In the case of steam boilers which are fitted with superheaters with no shut-off capability, at least two safety valves are to be located at the discharge from the superheater. Superheaters with shut-off capability are to be fitted with at least one safety valve.
Safety valves which are located at the discharge from the superheater shall be designed for at least 25% of the required blow-off capacity. When designing safety valves, allowance is to be made for the increase in the volume of steam caused by superheating.

2.9 Steam may not be supplied to the safety valves through pipes in which water may collect.

2.10 Safety valves shall be easily accessible and capable of being released safely during operation.

2.11 Safety valves are to be designed so that no binding or jamming of moving parts is possible even when heated to different temperatures. Seals which may prevent the operation of the safety valve due to frictional forces are not permitted.

2.12 Safety valves are to be set in such a way as to prevent unauthorized alteration.

2.13 Pipes or valve housings shall have a drain facility, which has no shut-off capability, fitted at the lowest point on the blow-off side.

2.14 Combined blow-off lines from several safety valves may not unduly impair the blow-off capability.

3. Water level indicators

3.1 Steam boilers which have their own steam chamber are to be fitted with two devices giving a direct reading of the water level.

3.2 Steam boilers which have their own steam space heated by exhaust gases whose temperature does not exceed 400 °C, are to be fitted with at least one device giving a direct reading of the water level.

3.3 External steam drums of boilers which do not have their own steam space are to be fitted with two devices giving a direct reading of the water level.

3.4 Cylindrical glass water level gauges are not permitted.

3.5 The water level indicators are to be fitted so that a reading of the water level is possible also when the unit is heeling (where required). The limit for the lower visual range has to be at least 30 mm above the highest flue, but a least 30 mm below the lowest water level. The lowest water level may not be above the centre of the visual range. The water level indicators shall be well illuminated and visible from the boiler control station.

3.6 The connection pipes between steam generator and water level indicators shall have an inner diameter of at least 20 mm. They shall be run in such a way that there are no sharp bends in order to avoid water and steam traps, and shall be protected from the effects of the heated gases and against cooling.

Where water level indicators are linked by means of common connection lines or where the connection pipes on the water side are longer than 750 mm, the connection pipes on the water side shall have an inner diameter of at least 40 mm.

3.7 Between the water level indicators and the water and steam chamber of the boiler easily accessible, simple to control and quick-acting shut-off devices have to be provided.

3.8 The devices used for blowing through the water level indicators shall be designed so that they are safe to operate and so that blow-through can be monitored. The discharging media are to be drained away safely.

3.9 Remote water level indicators and display equipment of a suitable type to give an indirect reading may be approved as additional display devices.

3.10 In place of water level indicators, once-through forced flow boilers shall be fitted with two mutually independent devices which trip an alarm as soon as water flow shortage is detected. An automatic device to shut down the heating system may be provided in place of the second warning device.

3.11 The cocks and valves of the water level indicators which cannot be directly reached by hand from floor plates or a control platform shall have a control facility using pull rods or chain pulls.

4. Pressure gauges

4.1 At least one pressure gauge directly connected to the steam space is to be fitted on each boiler. The allowable maximum working pressure is to be marked on the dial by means of a permanent and easily visible red mark. The indicating range of the pressure gauge shall include the testing procedure.

4.2 At least one additional pressure indicator having a sensor independent from the pressure gauge has to be located at the machinery control station or at some other appropriate site.

4.3 Where several steam boilers are incorporated on one plant, the steam chambers of which are linked together, one pressure gauge is sufficient at the plant control station or at some other suitable location, in addition to the pressure gauges on each boiler.

4.4 The pipe to the pressure gauge shall have a water trap and a blow-off device. A connection for a
test gauge shall be installed close to the pressure
gauge. In the case of pressure gauges which are at a
lower position the test connection shall be provided
close to the pressure gauge and also close to the con-
nection piece of the pressure gauge pipe.

4.5 Pressure gauges are to be protected against
radiant heat and shall be well illuminated.

5. Temperature gauges

5.1 A temperature gauge is to be fitted to the flue
gas outlets of fired steam boilers.

5.2 Temperature gauges are to be fitted to the
exhaust gas inlet and outlet of steam boilers heated by
exhaust gas.

5.3 Temperature gauges shall be fitted at the
outlets from superheaters or superheater sections, at
the inlet and outlet of attemperators, and also at the
outlet of once-through forced flow boilers, where this
is necessary to assess the behaviour of the materials
used.

6. Regulating devices (Controllers)

6.1 With the exception of boilers which are
heated by exhaust gas, steam boilers are to be operated
with rapid-control, automatic firing systems. The
control facility shall be capable of safely controlling
all operating conditions so that the steam pressure and
the temperature of the superheated steam stay within
safe limits and the supply of feed water is guaranteed.

6.2 Steam pressure shall be automatically regu-
lated by controlling the supply of heat. The steam
pressure of boilers heated by exhaust gas may also be
regulated by condensing the excess steam.

6.3 In the case of boilers which have a specified
minimum water level, the water level shall be regu-
lated automatically by controlling the supply of feed
water.

6.4 In the case of forced-circulation boilers
whose heating surface consists of a steam coil, and of
once-through forced flow boilers, the supply of feed
water may be regulated as a function of fuel supply.

6.5 In the case of steam boilers which are fitted
with superheaters, the temperature of the superheated
steam shall be automatically regulated unless the cal-
culated temperature is higher than the maximum at-
tainable temperature of the superheater walls.

7. Monitoring devices (Alarms)

7.1 A warning device is to be fitted which is
tripped when the specified maximum water level is
exceeded.

7.2 In exhaust-gas heated boilers, a warning
device is to be fitted which is tripped before the
maximum allowable working pressure is reached.

7.3 In exhaust-gas heated boilers with a specified
minimum water level, a warning device suitable for
this purpose is to be fitted which is tripped when the
water falls below this level.

7.4 Exhaust gas boilers with finned tubes are to
have a temperature monitor fitted in the exhaust gas
pipe which trips an alarm in the event of fire, see GL
Rules I - Ship Technology, Part 1 - Seagoing Ships,
Chapter 4 – Automation or further regulations in
agreement with the customer.

7.5 Where there is a possibility of oil or grease
getting into the steam or condensate system, a suitable
automatic and continuously operating unit is to be
installed which trips an alarm and cuts off the feed
water supply if the concentration at which boiler op-
eration is put at risk is exceeded.

7.6 Where there is a possibility of acid, lye or
seawater getting into the steam or condensate system,
a suitable automatic and continuously operating unit is
to be installed which trips an alarm and cuts off the
feed water supply if the concentration at which boiler
operation is put at risk is exceeded.

7.7 It shall be possible to carry out function test-
ing of the monitoring devices, even during operation,
if an equivalent degree of safety is not attained by
selfmonitoring of the equipment.

7.8 The monitoring devices shall trip visual and
audible fault warnings in the boiler room or in the
machinery control room or any other suitable site, see
GL Rules I – Ship Technology, Part 1 - Seagoing
Ships, Chapter 4 – Automation or further regulations
in agreement with the customer.

8. Safety devices (Limiters)

8.1 The suitability of safety devices for marine
use is to be proven by type testing.

The safety devices shall be suitable for the use on
steam boilers.

8.2 Fired boilers are to be equipped with a reli-
able pressure limiter which cuts off and interlocks the
firing system before the maximum allowable working
pressure is reached.

8.3 In steam boilers on whose heating surfaces a
highest flue is specified, two reliable, mutually inde-
pendent water level limiters shall respond to cut off
and interlock the firing system when the water falls
below the specified minimum water level. The water
level limiter shall also be independent of the water
level control devices.
8.4 The receptacles for water level limiters located outside the boiler shall be connected to the boiler by means of lines which have a minimum inner diameter of 20 mm. Shut off devices in these lines shall have a nominal diameter of at least 20 mm and shall indicate their open or closed position. Where water level limiters are connected by means of common connection lines, the connection pipes on the water side shall have an inner diameter of at least 40 mm.

Operation of the firing system shall only be possible when the shut off devices are open or else, after closure, the shut off devices shall reopen automatically and in a reliable manner.

Water level limiter receptacles which are located outside the boiler are to be designed in such a way that a compulsory and periodic blow-through of the receptacles and lines can be carried out.

8.5 In the case of forced-circulation boilers with a specified lowest water level, two reliable, mutually independent safety devices shall be fitted in addition to the requisite water level limiters, which will cut off and interlock the heating system in the event of any unacceptable reduction in water circulation.

8.6 In the case of forced-circulation boilers where the heating surface consists of a single coil, and of once-through forced flow boilers, two reliable, mutually independent safety devices shall be fitted in place of the water level limiters in order to provide a sure means of preventing any excessive heating of the heating surfaces by cutting off and interlocking the firing system.

8.7 In steam boilers with superheaters, a temperature limiter is to be fitted which cuts off and interlocks the heating system if the allowable super-heated steam temperature is exceeded. In the case of boiler parts which carry superheated steam and which have been designed to long-term resistance values, one temperature recording device is adequate.

8.8 The safety devices shall trip visual and audible alarms in the boiler room or in the machinery control room or any other appropriate site, see GL Rules, I - Ship Technology, Part 1 - Seagoing Ships, Chapter 4 - Automation.

8.9 The electrical devices associated with the limiters are to be designed in accordance with the closed-circuit principle so that, even in the event of a power failure, the limiters will cut off and interlock the systems unless an equivalent degree of safety is achieved by other means.

8.10 To reduce the effects due to sea conditions, where required, water level limiters can be fitted with a delay function provided that this does not cause a dangerous drop in the water level.

8.11 The electrical interlocking of the firing system following tripping by the safety devices may only be reset at the firing system control panel itself.

8.12 If an equivalent degree of safety cannot be achieved by the self-monitoring of the equipment, the safety devices shall be subjected to operational testing even during operation. In this case, the operational testing of water level limiters shall be carried out without the surface of the water dropping below the lowest indicated water level.

8.13 For details of additional requirements relating to once-through forced flow boilers, see 3.10.

9. Feed and circulation devices

9.1 For details of boiler feed and circulation devices, see Section 13e, C. The following requirements are also to be observed.

9.2 The feed devices are to be fitted to the steam boiler in such a way that it cannot be drained lower than 50 mm above the highest flue when the non-return valve is not tight.

9.3 The feed water is to be introduced into the boiler in such a way as to prevent damage occurring to the boiler walls and to heated surfaces. Proper treatment and adequate monitoring of the feed and boiler water are to be carried out.

10. Shut-off devices

10.1 Each steam boiler shall be capable of being shut off from all connected pipes. The shut-off devices are to be installed as close as possible to the boiler walls and shall operate without risk.

10.2 Where several boilers which have different maximum allowable working pressures give off their steam into common lines, it is necessary to ensure that the maximum working pressure allowable for each boiler cannot be exceeded in any of the boilers.

10.3 Where there are several boilers which are connected by common pipes and the shut-off devices for the steam, feed and drain lines are welded to the boilers, for safety reasons while the boilers are running, two tandem shut off devices which are to be protected against unauthorised operation are each to be fitted with an interposed release device.

11. Scum removal, sludge removal, drain and sampling devices

11.1 Boilers and external steam drums are to be fitted with devices to allow them to be drained and to have the sludge removed. Where necessary, boilers are to be fitted with a scum removal device.
11.2 Drain devices and their connections must be protected from the effects of the heating gases and capable of being operated without risk. Self-closing sludge removal valves shall be lockable when closed, or alternatively an additional shut-off device is to be fitted in the pipe.

11.3 Where the scum removal, sludge removal or drain lines from several boilers are combined, a non-return valve is to be fitted in the individual boiler lines.

11.4 The scum removal, sludge removal or drain lines, plus valves and fittings, are to be designed to allow for the maximum allowable working pressure of the boiler.

11.5 With the exception of once-through forced flow boilers, devices for taking samples from the water contained in the boiler are to be fitted to steam boilers.

11.6 Scum removal, sludge removal, drain and sampling devices shall be capable of safe operation. The media being discharged are to be drained away safely.

12. Name plate

12.1 A name plate is to be permanently affixed to each steam boiler, displaying the following information:

- manufacturer
- serial number and year of construction
- maximum allowable working pressure [bar]
- steam production [kg/h] or [t/h]
- permitted temperature of super-heated steam in °C provided that the boiler is fitted with a super-heater with no shut off capability

12.2 The name plate shall be permanently attached to the largest part of the boiler or to the boiler frame so that it is visible.

13. Valves and fittings

13.1 Materials

Valves and fittings for boilers shall be made of ductile materials as defined in the relevant design rules according to A.2.1. and all their components must be able to withstand the loads imposed in operation, in particular thermal loads and possible stresses due to vibration. Grey cast iron may be used within the limits specified in the relevant design rules according to A.2.1, but may not be employed for valves and fittings which are subjected to dynamic loads, e.g. safety valves and blow-off valves.

Testing of materials for valves and fittings is to be carried out as specified in Table 12a.1.

13.2 Design

Care is to be taken to ensure that the bodies of shut off gate valves cannot be subjected to unduly high pressure due to heating of the enclosed water. Valves with screw-on bonnets shall be safeguarded to prevent unintentional loosening of the bonnet.

13.3 Pressure and tightness tests

13.3.1 All valves and fittings are to be subjected to a hydrostatic pressure test at 1,5 times the nominal pressure before they are fitted. Valves and fittings for which no nominal pressure has been specified are to be tested at twice the working pressure. In this case, the safety factor in respect of the 20 °C yield strength value may not fall below 1,1.

13.3.2 The sealing efficiency of the closed valve is to be tested at the nominal pressure or at 1,1 times the working pressure, as applicable.

Valves and fittings made of castings and subject to operating temperatures over 300 °C are required to undergo one of the following tightness tests:

a) tightness test with air (test pressure approximately 0,1 x working pressure; maximum 2 bar,

b) tightness test with saturated or superheated steam (test pressure may not exceed the maximum allowable working pressure);

c) tightness test may be dispensed with if the pressure test is performed with petroleum or other liquid displaying similar properties.

13.3.3 Pressure tests and tightness tests of valves and fittings shall be carried in the presence of the GL Surveyor.

14. Installation of boilers

14.1 Mounting

Boilers have to be installed with care and shall be secured to ensure that they cannot be displaced by any of the circumstances arising when the unit is at sea. Means are to be provided to accommodate the thermal expansion of the boiler in service. Boilers and their seating must be easily accessible from all sides or must be easily rendered so.

14.2 Fire precautions

See Section 10.
F. Testing of Boilers

1. Constructional test

After completion, boilers are to undergo a constructional test.

The constructional test includes verification that the boiler agrees with the approved drawing and is of satisfactory construction. For this purpose, all parts of the boiler shall be accessible to allow adequate inspection. If necessary, the manufacturing test is to be performed at separate stages of manufacture.

The following documents are to be presented: material test Certificates covering the materials used, reports on the non-destructive testing of welds and, where applicable, the results of tests of workmanship and proof of the heat treatment applied.

2. Hydrostatic pressure tests

2.1 A hydrostatic pressure test is to be carried out on the boiler before the refractory, insulation and casing are fitted. Where only some of the component parts are sufficiently accessible to allow proper visual inspection, the hydrostatic pressure test may be performed in stages. Boiler surfaces shall withstand the test pressure without leaking or suffering permanent deformation.

2.2 The test pressure is generally required to be 1,5 times the maximum allowable working pressure. In case the maximum allowable working pressure is less than 2 bars the test pressure has to be at least 1 bar higher than the maximum allowable working pressure.

2.3 In the case of once-through forced flow boilers, the test pressure shall be at least 1,1 times the water inlet pressure when operating at the maximum allowable working pressure and maximum steam output.

2.4 In the event of danger that parts of the boiler might be subjected to stresses exceeding 0,9 of the yield strength, the hydrostatic test may be performed in separate sections. The maximum allowable working pressure is then deemed to be the pressure for which the particular part of the boiler has been designed.

2.4 For boiler parts subject to internal and external pressures which invariably occur simultaneously in service, the test pressure depends on the differential pressure. In these circumstances, however, the test pressure should at least be equal to 1,5 times the design pressure specified in D.1.2.

3. Constructional test and hydrostatic pressure test shall be carried out by or in presence of the GL Surveyor.

G. Hot Water Generators

1. Scope

Hot water generators with a permissible discharge temperature > 120 °C, which are heated by liquid or gaseous fuels or by exhaust gases or electrically, are to be treated in a manner analogous to that applied to boilers. The materials and strength calculations for hot water generators which are heated by steam or hot liquids are subject to the requirements in Section 12 c-Pressure Vessels.

2. Equipment

The safety equipment of hot water generators is subject to the requirements contained in E. as appropriate.

3. Testing

Each hot water generator is to be subjected to a constructional test and to a hydrostatic pressure test at 1,5 times the maximum allowable working pressure subject to a minimum of 4 bar in presence of a GL Surveyor.

H. Flue Gas Economizers

1. Definition

Flue gas economizers are preheaters arranged in the flue gas duct of boilers used for preheating of feedwater without any steam being produced in service. They can be disconnected from the water side of the boiler.

The surfaces of the preheater comprise the water space wall located between the shut off devices plus the casings of the latter. Water may be taken from the economizer only if the boiler feed system is specially designed for the purpose.

2. Materials

See provisions under B.

3. Design calculation

The formulae given under D. are to be applied in the calculation. The design pressure is to be at least the maximum allowable working pressure of the economizer.

The design temperature is the maximum feedwater temperature plus 25 °C for plain tube economizers and plus 35 °C for finned tube economizers.
The feedwater temperature at the economizer outlet should be 20 °C below the saturation temperature corresponding to the working pressure of the boiler.

4. Equipment

4.1 Pressure gauges
The inlet side of each economizer is to be provided with a reliable pressure gauge as well as with a connection for a test pressure gauge. The maximum allowable working pressure of the economizer is to be marked by a red line on the scale of the pressure gauge.

4.2 Safety valves
Each economizer is to be equipped with a spring-loaded safety valve with an inside diameter of at least 15 mm which is to be set at most to the maximum allowable working pressure of the economizer.

The safety valve is to be designed so that, even if shut-off devices between the economizer and the boiler are closed, the maximum allowable working pressure of the economizer is not exceeded by more than 10 %.

4.3 Temperature measuring device
Each economizer is to be equipped with at least one temperature measuring device giving a reliable reading of the feedwater temperature at the outlet of the economizer. The permissible outlet temperature of the feedwater is to be marked in red on the temperature gauge.

4.4 Shut-off devices
Each economizer is to be equipped with shut-off devices at the feedwater inlet and outlet. The boiler feed valve may be regarded as one of these shut-off devices.

4.5 Discharge and venting equipment
Each economizer is to be provided with means of drainage and with vents for all points where air may gather, enabling it to be satisfactorily vented even when in operation.

4.6 Means for preventing the formation of steam in economizers
Suitable equipment is to be fitted to prevent steam from being generated in the economizer, e.g. when the steam supply is suddenly stopped. This may take the form of a circulating line from the economizer to a feedwater tank to enable the economizer to be cooled, or of a by-pass enabling the economizer to be completely isolated from the flue gas flow.

5. Name plate
A name plate giving the following details is to be fitted to every economizer:

- manufacturer's name and address
- serial number and year of manufacture
- maximum allowable working pressure of the economizer in bar

6. Tests
Before they are installed, finished economizers are to be subjected at the maker's works to a constructional test and a hydrostatic pressure test at 1.5 times the maximum allowable working pressure in the presence of a GL Surveyor.
Section 12b

Thermal Oil Systems

A. General

1. Scope
The following requirements apply to thermal oil systems in which organic liquids (thermal oils) are heated by gas or oil fired burners, exhaust gases or electricity to temperatures below their initial boiling point at atmospheric pressure.

2. Other applicable requirements
In addition to the provisions of this Section, the Chapters/Sections listed in the following are to be applied analogously:

- Section 12a  For materials, fabrication and design of the heaters
- Section 12c  For materials, fabrication and design of the expansion vessels and the tanks
- Section 12d  For gas or oil firing systems (additional shutdown criteria) see B.4.
- Section 13a, D.  For thermal oil tanks (storage tanks)
- Section 13e, J.  For pipes, valves and pumps
- Section 10  For fire protection and fire fighting equipment
- Chapter 6  For electrical equipment items

3. Definitions

3.1 Maximum allowable working pressure
The maximum allowable working pressure PB is the maximum pressure which may occur in the individual parts of the equipment under service conditions.

3.2 Thermal oil temperature
The thermal oil temperature is the temperature of the thermal oil at the centre of the flow cross-section.

3.3 Discharge temperature
The discharge temperature is the temperature of the thermal oil immediately at the heater outlet.

3.4 Return temperature
The return temperature is the temperature of the thermal oil immediately at the heater inlet.

3.5 Film temperature
The film temperature is the wall temperature on the thermal oil side. In the case of heated surfaces, this may differ considerably from the temperature of the thermal oil.

4. Documents for approval
The following documents are to be submitted for approval:

- a description of the system stating the discharge and return temperatures, the maximum allowable film temperature, the total volume of the system and the physical and chemical characteristics of the thermal oil
- drawings of the heaters, the expansion and other vessels and the drainage and storage tanks
- a functional diagram with information about the safety devices and valves provided (for information)
- circuit diagrams of the electrical control system, respectively monitoring and supervision
- If specially requested, mathematical proof of the maximum film temperature in accordance with DIN 4754 is to be submitted.

5. Thermal oils

5.1 The thermal oil shall remain serviceable for at least 1 year at the specified thermal oil temperature.
Its suitability for further use is to be verified at appropriate intervals, but at least once a year.

5.2 Thermal oils may only be used within the limits set by the manufacturer. A safety margin of about 50 °C is to be maintained between the discharge temperature and the maximum allowable film temperature specified by the manufacturer.

5.3 Precautions are to be taken to protect the thermal oil from oxidation.

5.4 Copper and copper alloys are to be avoided due to their catalytic effect on the thermal oil.
6. Manual operation

6.1 The facility is to be provided for manual operation. At least the temperature limiters on the oil side and flow monitoring must remain operative even in manual operation.

6.2 Manual operation demands constant and direct supervision of the system.

6.3 For details of requirements in respect of the manual operation of the gas or oil firing system, see Section 12d.

B. Heaters

1. Acceptable materials

Heaters of thermal oil system are to be fabricated from the same materials as boilers, see Section 12a.

2. Testing of materials

The materials of the parts of the heaters which are in contact with the thermal oil are to be tested in accordance with Section 12a.

For coils with a maximum allowable working pressure up to 10 bar Manufacturer Inspection Certificates according to GL Rules II – Materials and Welding, Part 1 – Metallic Materials, Chapter 1 – Principles and Test Procedures, Section 1, H. are sufficient.

3. Design

3.1 Heaters are to be designed thermodynamically and by construction so that neither the surfaces nor the thermal oil become excessively heated at any point. The flow of the thermal oil must be ensured by forced circulation.

3.2 The surfaces which come into contact with the thermal oil are to be designed for the maximum allowable working pressure subject to a minimum gauge pressure of 10 bar.

3.3 Heaters heated by exhaust gas shall be so designed that damage caused by resonances resulting from oscillation of the exhaust gas column cannot occur.

3.4 The exhaust gas intake shall be arranged that the thermal oil cannot penetrate the engine or the turbocharger in case of a leakage in the heater respectively the cleaning medium during heater cleaning.

3.5 Heaters heated by exhaust gas are to be provided with manholes serving as inspection openings at the exhaust gas intake and outlet.

3.6 Oil fired heaters are to be provided with inspection openings for examination of the combustion chamber.

3.7 Sensors for temperature measuring and monitoring devices are to be introduced into the system through welded-in immersion pipes.

3.8 Heaters are to be fitted with means enabling them to be completely drained.

3.9 For electrically heated heaters the requirements are to be applied analogously to gas or oil fired heaters.

4. Equipment

4.1 Suitability

The suitability of safety and monitoring devices (e.g. valves, limiters/alarms for temperature, flow and leakage monitoring) for the intended use is to be proven by type testing.

4.2 Safety valves

Each heater is to be equipped with at least one safety valve having a blow-off capacity at least equal to the increase in volume of the thermal oil at the maximum heating power. During blow-off, the pressure may not increase more than 10 % above the maximum allowable working pressure.

4.3 Temperature and flow indicating devices

4.3.1 Temperature measuring devices are to be fitted at the discharge and return line of both gas or oil fired heaters and heaters by exhaust gas.

4.3.2 Temperature measuring devices are also to be fitted in the flue gas or exhaust gas stream at the heater’s outlet.

4.3.3 The flow of the thermal oil shall be indicated.

4.4 Temperature control

4.4.1 For automatic control of the discharge temperature, gas or oil fired heaters are to be equipped with an automatic rapidly adjustable heat supply in accordance with Section 12d.

4.4.2 The discharge temperature of heaters heated by exhaust gas shall be controlled by automatic regulation of the heat input or by recooling the thermal oil in a dumping cooler.

4.5 Temperature monitoring

4.5.1 If the allowable discharge temperature is exceeded, for gas or oil fired heaters the heat supply shall be switched off and interlocked by a temperature limiter.
4.5.2 If the allowable discharge temperature is exceeded, for heaters heated by exhaust gas an alarm shall be tripped.

4.5.3 The discharge temperature of parallel-connected heating surfaces in the heater shall be monitored individually at the outlet of each heating surface. With heaters heated by exhaust gas, individual monitoring of heater surfaces connected in parallel may be dispensed with if the maximum exhaust gas temperature is lower than the maximum allowable film temperature of the thermal oil.

4.5.4 If the specified flue gas temperature of gas or oil fired heaters is exceeded, the firing system must be switched off and be interlocked.

4.5.5 Heaters heated by exhaust gases are to be equipped with a temperature switch which, when the maximum design exhaust gas temperature is exceeded, signals by means of an alarm that the heating surfaces could be badly fouled.

4.6 Flow monitoring

4.6.1 Precautions shall be taken to ensure that the maximum allowable film temperature of the thermal oil is not exceeded.

4.6.2 A flow monitor, switched as a limiter, shall be provided for gas or oil fired heaters. If the flow rate falls below a minimum value, the firing system shall be switched off and be interlocked.

4.6.3 Start-up of the burner shall be prevented by interlocks if the circulating pump is stationary.

4.6.4 A flow monitor switched as an alarm shall be provided at heaters heated by exhaust gas.

4.6.5 An alarm is to be provided in case the engine, which delivers exhaust gas to the heater, is started while the circulating pump is stationary.

4.7 Leakage monitoring

4.7.1 Gas or oil fired heaters are to be equipped with a leakage detector which, when actuated, shuts down and interlocks the firing system. If the gas or oil fired heater is on “stand-by”, the starting of the burner must be blocked if the leakage detector is actuated.

4.7.2 Heaters heated by exhaust gas are to be equipped with a leakage detector which, when actuated, trips an alarm, and a reference shall be provided to reduce the power of the engine which delivers exhaust gas to the heater.

4.8 Shut-off devices

4.8.1 Both gas or oil fired heaters and heaters heated by exhaust gas are to be fitted with shut-off devices and if necessary with by-pass valves, which can also be operated from a position outside the immediate area in which the heater is installed.

4.8.2 It is advisable for the heater to be capable of being drained and ventilated from the same position.

4.9 Fire detection and fire extinguishing system

4.9.1 The temperature switch for fire detection required according to Section 10 shall be provided additionally to the temperature switch according to 4.5.5 and shall be set to a temperature 50 to 80 °C higher. If actuated, alarm shall be given by group alarm.

4.9.2 Thermal oil heaters heated by exhaust gas are to be fitted with a permanent system for extinguishing and cooling in the event of fire, e.g. a pressure water spraying system. For details see Section 10.

C. Vessels

1. Acceptable materials

Vessels are to be fabricated from materials conforming to Section 12c in the pressure vessels class appropriate to the thermal oil system.

2. Testing of materials

The vessel materials are to be tested in accordance with Section 12c.

3. Design

3.1 All vessels, including those open to the atmosphere, are to be designed for a pressure of at least 2 bar, unless provision has to be made for a higher working pressure. Excepted from this rule are tanks designed and dimensioned according to Chapter 4, Sections 3 to 5.

3.2 An expansion vessel is to be placed at a high level in the system. The space provided for expansion shall be such that the increase in the volume of the thermal oil at the maximum thermal oil temperature can be safely accommodated. The following requirements are to be regarded as a minimum: 1.5 times the stipulated increase in volume for volumes up to 1000 litres, and 1.3 times the increase for volumes over 1000 litres. The volume is the total quantity of thermal oil contained in the equipment up to the lowest liquid level in the expansion vessel.

3.3 At the lowest point of the system a drainage tank is to be located, the capacity of which is sufficient to hold the volume of the largest isolatable system section.
3.4 A separate storage tank is to be provided to compensate any losses. The stock of thermal oil is to be at least 40% of the capacity of the system.

3.5 In exceptional cases, approval may be given for the drainage tank and the storage tank to be combined. Combined storage/drainage tanks are to be so dimensioned that, in addition to the stock of thermal oil, there is room for the contents of the largest isolatable system section.

4. **Equipment of the expansion vessel**

4.1 **Suitability**

The suitability of level indication devices, safety and monitoring devices (e.g. low level limiter) for the intended use is to be proven by type testing.

4.2 **Level indication**

4.2.1 The expansion vessel shall be equipped with a liquid level gauge with a mark indicating the lowest allowable liquid level.

4.2.2 Level gauges made of glass or plastic are not allowed.

4.3 **Low level limiter and pre-alarm**

4.3.1 A limit switch is to be fitted which shuts down and interlocks the firing system and switches off the circulating pumps if the liquid level falls below the allowable minimum.

4.3.2 Additionally a pre-alarm for low liquid level is to be installed, e.g. by means of an adjustable level switch on the level indication device which gives an early warning of a falling liquid level (e.g. in the event of a leakage).

4.3.3 An alarm is also to be provided for the maximum liquid level.

4.4 **Quick drainage valve and emergency shut off valve**

4.4.1 For rapid drainage in case of danger, a quick drainage valve is to be fitted directly to the vessel, with remote control from outside the space in which the equipment is installed.

4.4.2 Automatic means shall be provided to ensure a sufficient air supply to the expansion vessel when the quick drainage valve is operated.

4.4.3 Where the expansion vessel is installed outside the engine room, the quick drainage valve may be replaced by an emergency shut-off device.

4.4.4 The opening of the quick drainage valve or the operation of the emergency shut-off device, as applicable, shall cause the automatic shutdown of the firing system and the circulating pumps.

4.5 **Connection lines**

4.5.1 A safety expansion line shall connect the system to the expansion vessel. This line shall be installed with a continuous positive gradient and shall be dimensioned that a pressure rise of more than 10% above the maximum allowable working pressure in the system is avoided.

4.5.2 The expansion vessel is to be provided with an overflow line leading to the drainage tank.

4.5.3 The quick drainage line may be routed jointly with the overflow line to the drainage tank.

4.5.4 All parts of the system in which thermal oil can expand due to the absorption of heat from outside must be safeguarded against excessive pressure. Any thermal oil emitted is to be safely drained off.

4.6 **Pre-pressurized system**

4.6.1 Pre-pressurized systems are to be equipped with an expansion vessel which contents are blanketed with an inert gas. The inert gas supply to the expansion vessel has to be guaranteed.

4.6.2 The pressure in the expansion vessel must be indicated and the vessel safeguarded against overpressure.

5. For the equipment of the drainage and storage tanks see Section 13a.

D. **Equipment Items**

1. **Acceptable materials**

1.1 For materials for pipes, valves and pumps see Section 13b.

1.2 Grey cast iron is unacceptable for equipment items in the hot thermal oil circuit and for safety valves.

2. **Testing of materials**

Pipe, valve and pump materials are to be tested in accordance with Section 12a, 13b and 13c.

3. **Design requirements**

3.1 Pipes, valves and pumps are governed, in addition to the following specifications, by the provisions of Section 13b-e.
3.2 The outlets of the circulating pumps are to be equipped with pressure gauges.

3.3 It shall be possible to shut down the circulating pumps by an emergency switch which can also be operated from a position outside the room in which the pumps are installed.

3.4 Devices for safe sampling are to be provided at a suitable location in the thermal oil circuit.

3.5 Means of venting are to be provided at the highest points of the isolatable sections of the thermal oil system, and drains or drainage devices at the lowest points. Venting and drainage via open funnels are to be avoided.

3.6 For filling and draining pumps see Section 13e.

3.7 Electric equipment items are governed by Chapter 6 – Electrical Installations.

E. Marking

1. Heaters

The followings information shall be stated on a durable manufacturer’s name plate permanently attached to the heater:

- manufacturer's name and address
- serial number
- year of manufacture
- maximum allowable heating power
- maximum allowable working pressure
- maximum allowable discharge temperature
- minimum flow rate
- liquid capacity

2. Vessels

2.1 Vessels are to be fitted with name plates bearing the following information:

- manufacturer's name and address
- serial number
- year of manufacture
- maximum allowable working pressure
- maximum allowable working temperature
- capacity

2.2 For vessels with an open connection to the atmosphere, the maximum allowable working pressure is to be shown on the name plate as "0" or "Atm.", even though a gauge pressure of 2 bar is taken as the design basis in accordance with C.

F. Fire Precautions

The fire precautions are governed by the provisions of Section 10.

G. Testing

1. Heaters

The thermal oil heaters are to be subjected to a constructional and hydrostatic pressure test, at 1.5 times the maximum allowable working pressure, at the manufacturer's works in the presence of the GL Surveyor.

2. Thermal oil system

After completion of installation, the system including the associated monitoring equipment is to be subjected to pressure, tightness and functional tests in the presence of the GL Surveyor.
Section 12c

Pressure Vessels, Heat Exchangers and Filters

A. General

1. Scope

1.1 The following requirements apply to pressure vessels, heat exchangers and filters (gauge or vacuum pressure) for the operation of offshore installations or units if they are subjected to internal or external pressure in service.

1.2 The Rules apply to a limited extent only (see 1.4) to pressure vessels and equipment with a maximum allowable working pressure of up to 1 bar gauge and with a total capacity, without deducting the volume of internal fittings, of not more than 1000 l and likewise to pressure vessels with a capacity of ≤ 0.5 l.

1.3 Installation’s/unit’s pressure vessels manufactured to recognized standards, e.g. pressure vessels for the water supply system, calorifiers and charge air coolers, are not subject to these requirements with respect to their wall thickness or the materials used. In the case of charge air coolers an examination of the drawings can be dispensed with.

1.4 The pressure vessels and equipment mentioned in 1.2 and 1.3 are demonstrated to the GL Surveyor for final inspection (constructional survey) and to be subjected to a hydrostatic pressure test in accordance with F.2. in his presence.

1.5 Hot water generators with outlet temperatures above 120 °C which are heated by liquid or gaseous fuels, by exhaust gases or by electrical means, as well as to economizers heated by flue gas are subject to Section 13a.

For reservoirs in hydraulic systems see also Section 13a.

For filter arrangements see also Section 3, G.3.

2. Design rules

2.1 For the construction of pressure vessels and heat exchangers the following Rules are applicable:

- GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 8
- AD Merkblätter (German Pressure Vessel Rules)
- BS 5500, Unfired Fusion Welded Pressure Vessels (British Standard)
- ASME Code Section VIII, Div. 1 and Div. 2, Rules for Construction of Pressure Vessels (American Society of Mechanical Engineers)

2.2 As regards their construction and installation, pressure vessels plants are also required to comply with the applicable statutory requirements and regulations of the installation’s/unit’s country of registration.

3. Documents for approval

Drawings of pressure vessels and equipment containing all the data necessary for their safety assessment are to be submitted to GL in triplicate. The following details, in particular, are to be specified:

- intended use, volume of the individual compartments
- working pressure and temperatures, if necessary, secondary loads, volume of the individual spaces
- materials to be used, details of welding techniques, heat treatment and non-destructive examination
- welding procedure specifications and procedure quality records
- design details of pressurized parts

B. Materials

1. General requirements

1.1 The materials of parts subject to pressure shall be suitable for the intended use and comply with the relevant GL Rules II – Materials and Welding, Part 1 – Metallic Materials.

1.2 Parts such as ribs or girths, holders, supports, brackets, etc. welded directly to pressure vessels walls are to be, made of material compatible with that of the wall, and of guaranteed weldability.

1.3 Welded structures are also subject to the GL Rules II – Materials and Welding, Part 3 – Welding.

1.4 For corrosion protection see C.7.

2. Classes

2.1 Depending on operating conditions, vessels are to be classed in accordance with Table 12c.1.
Table 12c.1 Pressure vessel classes

<table>
<thead>
<tr>
<th>Operating medium</th>
<th>Design pressure $p_c$ [bar]</th>
<th>Design temperature $t$ [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Liquefied gases (propan, butane, etc.), toxic and corrosive media</td>
<td>All</td>
<td>–</td>
</tr>
<tr>
<td>Refrigerants</td>
<td>Group 2</td>
<td>Group 1</td>
</tr>
<tr>
<td>Steam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>compressed air, Other gases</td>
<td>$p_c &gt; 16$</td>
<td>$p_c \leq 16$</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>$t &gt; 300$</td>
</tr>
<tr>
<td></td>
<td>$p_c \leq 16$</td>
<td>$t \leq 300$</td>
</tr>
<tr>
<td>Thermal oils</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p_c &gt; 16$</td>
<td>$p_c \leq 16$</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>$t &gt; 300$</td>
</tr>
<tr>
<td>Liquid fuels, lubricating oils, flammable hydraulic fluids</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p_c &gt; 16$</td>
<td>$p_c \leq 16$</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>$t &gt; 150$</td>
</tr>
<tr>
<td>Water, non-flammable hydraulic fluids</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p_c &gt; 40$</td>
<td>$p_c \leq 40$</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>$t &gt; 300$</td>
</tr>
</tbody>
</table>

2.2 Pressure vessels filled partly with liquids and partly with air or gases or which are blown out by air or gases, such as pressure tanks in drinking water or sanitary systems and reservoirs, are to be classified as pressure vessels containing air or gas.

3. Approved materials

The materials specified in the relevant rules (see A.2) are to be used for the construction. Special requirements are to be observed for pressure vessels and heat exchangers in sour service.

4. Testing of Materials

4.1 The materials of the following pressurized parts of pressure vessels with class I shall be tested by GL in accordance with the relevant rules and attested as GL Material Certificate according to the GL Rules II – Materials and Welding, Part I – Metallic Materials, Chapter 1 – Principles and Test Procedures; Section 1, H.

a) All parts subject to pressure with the exception of small parts such as welded pads, reinforcing discs, branch pieces and flanges of nominal diameter ≤ DN 50 mm, as well as forged or rolled steel valve heads for compressed air receivers.

b) Forged flanges for service temperatures > 300 °C, and for service temperatures ≤ 300 °C if the product of PB [bar] × DN (nominal diameter in mm) is > 2500 or the nominal diameter DN is > 250.

c) Bolts of size M 30 (30 mm diameter metric thread) and above made of steels with a tensile strength of more than 500 N/mm² and alloy or heat-treated steel bolts above M 16.

d) Nuts of size M 30 and above made of steels with a tensile strength of more than 600 N/mm².

e) Bodies of valves and fittings, see Section 13c.

4.2 For pressure vessel class II parts subject to mandatory testing, proof of material quality may take the form of Manufacturer Inspection Certificates according to the GL Rules defined in 4.1 provided that the test results certified therein comply with the GL Rules II – Materials and Welding.

Manufacturer Inspection Certificates according to the GL Rules defined in 4.1 may also be recognized for series-manufactured class I vessel components made of unalloyed steels, e.g. hand- and manhole covers, and for forged flanges and branch pipes where the product PB [bar] × DN [mm] ≤ 2500, the nominal bore DN ≤ 250 mm and service temperatures of ≤ 300 °C.

4.3 For all parts not subject to testing of materials by GL, alternative proof of the characteristics of the material is to be provided, e.g. a Manufacturer Test Report according to the GL Rules defined in 4.1 indicating the properties of the materials used.
C. Manufacturing Principles

1. Manufacturing processes

Manufacturing processes shall be compatible with the materials concerned. Materials the grain structure of which has been adversely affected by hot or cold working are to undergo heat treatment in accordance with the relevant rules.

2. Welding

2.1 The approval of welding shops and the qualification testing of welders are to be in accordance with the GL Rules II – Material and Welding.

2.2 For the execution of welds the relevant Chapters of the following Rules are to be applied:
   - GL Rules II – Materials and Welding, Part 3 – Welding
   - AD Merkblätter, Sequence HP
   - ASME Code, Section IX
   - BS 5500, Section 3 and 4

3. End plates

3.1 The flanges of dished ends may not be unduly hindered in their movement by any kind of fixtures, e.g. fastening plates or stiffeners. Supporting legs may only be attached to dished ends which have been adequately dimensioned for this purpose.

3.2 Where covers or ends are secured by hinged bolts, the latter are to be safeguarded against slipping off.

4. Branch pipes

The wall thickness of branch pipes shall be dimensioned as to enable additional external stresses to be safely absorbed. The wall thickness of welded-in branch pipes shall be appropriate in relation to the wall thickness of the part into which they are welded.

The wall shall be effectively welded together. (Full penetration welds required for vessel classes I and II).

Pipe connections in accordance with Section 13d are to be provided for the attachment of piping.

5. Tube plates

Tube holes shall be carefully drilled and deburred. Bearing in mind the tube expansion procedure and the combination of materials involved, the ligament width must be such as to ensure the proper execution of the expansion process and a sufficient anchorage of the tubes. The expanded length should not be less than 12 mm.

6. Compensation for thermal expansion

The design of vessels and equipment is to take account of possible thermal expansion, e.g. between the shell and nest of heating tubes.

7. Corrosion protection

Vessels and equipment exposed to accelerated corrosion owing to the medium which they contain (e.g. warm seawater) shall be protected in a suitable manner.

8. Cleaning and inspection openings

8.1 Vessels and equipment are to be provided with inspection and access openings which should be as large as possible and conveniently located. For the minimum dimensions of the openings, see Section 12a, C.8.

In order to provide access with auxiliary or protective devices, a manhole diameter of at least 600 mm is generally required. The diameter may be reduced to 500 mm where the pipe socket height to be traversed does not exceed 250 mm.

Vessels over 2.0 m in length shall have inspection openings at each end at least or shall contain a manhole.

Pressure vessels with an inside diameter of more than 800 mm shall be equipped at least with one manhole.

8.2 Manhole openings shall be designed and located in such a way that the vessels are accessible without undue difficulty. The edges of inspection and access openings are to be stiffened where they could be deformed by tightening the cover-retaining bolts or crossbars.

Special inspection and access openings are not necessary where internal inspection can be carried out by removing or dismantling parts.

8.3 Inspection openings may be dispensed with where experience has proven the unlikelihood of corrosion or deposits, e.g. in steam jackets.

Where vessels and equipment contain dangerous substances (e.g. liquefied or toxic gases), the covers of inspection and access openings shall be secured not by crossbars but by bolted flanges.

9. Identification and marking

Each pressure vessel is to be provided with a name plate or permanent inscription indicating as the minimum the following:
   - manufacturer
   - serial number
   - equipment TAG number (of the plant system)
D. Design Calculations

1. Principles

1.1 The parts subject to pressure of pressure vessels and equipment are to be designed by applying the formulae in accordance with the rules noted in A.2., in so far as they are applicable.

1.2 Design pressure p_c

1.2.1 The design pressure is generally the maximum allowable working pressure (gauge). In determining the maximum allowable working pressure due attention is to be given to hydrostatic pressures if these cause the loads on the walls to be increased by 5 % or more.

1.2.2 In the case of feedwater heaters located on the delivery side of the boiler feed pump, the maximum allowable working pressure is the maximum delivery pressure of the pump.

1.2.3 For external pressures, the calculation is to be based on a vacuum of 1 bar or on the external pressure at which the vacuum safety valves are actuated. In the event of simultaneous positive pressure externally and vacuum internally, or vice versa, the calculation is to assume an external or, respectively, internal pressure increased by 1 bar.

1.3 Allowable stress

1.3.1 The dimensions of components are governed by the allowable stress \( \sigma_{zul} \) [N/mm²] to be determined in accordance with the relevant rules. The stress, however, shall not exceed the lowest of the values resulting from the following expressions.

1.3.2 Rolled and forged steels

For design temperatures up to 350 °C:

\[
\sigma_{zul} = \min \left\{ \frac{R_{m,20^\circ}}{2.7}, \frac{R_{eH,20^\circ}}{1.7}, \frac{R_{eH,t}}{1.6} \right\}
\]

\( R_{m,20^\circ} \) = guaranteed minimum tensile strength [N/mm²] at room temperature (may be dispensed with in the case of recognized fine grain steels with \( R_{mH} \leq 360 \text{ N/mm}^2 \))

\( R_{eH,20^\circ} \) = guaranteed yield strength or minimum value of the 0.2 % proof stress at room temperature (1 % proof stress in case of austenitic steel)

\( R_{eH,t} \) = guaranteed yield strength or minimum value of the 0.2 % proof stress at design temperatures above 50 °C (1 % proof stress in case of austenitic steel)

For design temperature over 350 °C:

\[
\sigma_{zul} = \frac{R_{m,100000,t}}{1.5}
\]

\( R_{m,100000,t} \) = mean value of the 100000 h fatigue strength at design temperature t

Tanks for liquefied gases are governed by the values specified in the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 6 – Liquefied Gas Tankers or equivalent recognised standards.

1.3.3 Cast materials

a) Cast steel

\[
\sigma_{zul} = \min \left\{ \frac{R_{m,20^\circ}}{3.2}, \frac{R_{eH,t}}{2.0}, \frac{R_{m,100000,t}}{2.0} \right\}
\]

b) Nodular cast iron

\[
\sigma_{zul} = \min \left\{ \frac{R_{m,20^\circ}}{4.8}, \frac{R_{eH,t}}{3.0} \right\}
\]

c) Grey cast iron

\[
\sigma_{zul} = \frac{R_{eH,20^\circ}}{11}
\]

1.3.4 Non-ferrous metals

a) Copper and copper wrough alloys:

\[
\sigma_{zul} = \frac{R_{m,t^\circ}}{4.0}
\]

b) Aluminium and aluminium wrough alloys:

\[
\sigma_{zul} = \frac{R_{m,t^\circ}}{4.0}
\]

With non-ferrous metals supplied in varying degrees of hardness is should be noticed that heating, due e.g. to soldering or welding, can cause a reduction in mechanical strength. In these cases, calculations are to be based on the mechanical strength in the soft annealed condition.
1.4  Design temperature

1.4.1  The design temperature to be applied is generally the maximum temperature of the medium to be contained.

1.4.2  Where heating is done by firing, exhaust gas or electrical means, Table 12a.2 is to be applied as appropriate. Where electrical heating is used, Table 12a.2 applies only to directly heated surfaces.

1.4.3  With service temperatures below 20 °C, a design temperature of at least 20 °C is to be used in calculations.

1.5  Weakening factor

For the weakening factors v for the calculation of walls or parts of walls the relevant Rules shall be applied.

1.6  Allowance for corrosion and wear

The allowance for corrosion and wear is generally c = 1 mm. The experience of the designer and purchaser has to be considered. It may be dispensed with in the case of plate thicknesses of 30 mm or more, stainless steels or other corrosion-resistant materials.

1.7  Minimum wall thickness

1.7.1  The wall thickness of the shell and end plates shall generally not be less than 3 mm.

1.7.2  Where the walls of vessels are made from pipes or for vessels and equipment in class III a minimum wall thickness of 2 mm can be allowed, provided that the walls are not subjected to external forces.

1.8  Other methods applicable to dimensional design

Where walls, or parts of walls, cannot be calculated by applying the formulae given in Section 12a or in accordance with the general rules of engineering practice, other methods are to be used to demonstrate that the allowable stresses are not exceeded.

E.  Equipment and Installation

1.  Shut-off devices

Shut-off devices have to be fitted in pressure lines as close as possible to the pressure vessel. Where several pressure vessels are grouped together, it is not necessary that each vessel should be capable of being shut-off individually and means need only be provided for shutting-off the group. In general, not more than three vessels shall be grouped together. Starting air receivers and other pressure vessels which are opened in service shall be capable of being shut-off individually.

Devices incorporated in piping (e.g. water and oil separators) do not require shut-off devices.

2.  Pressure gauges

2.1  Each pressure vessel which can be shut-off and every group of vessels with a shut-off device shall be equipped with a pressure gauge, suitable for the medium contained in the vessel and also capable of being shut-off. The measuring range and calibration shall extend to the test pressure, with a red mark to indicate the maximum allowable working pressure.

2.2  Equipment need only be fitted with pressure gauges when this is necessary for its operation.

3.  Safety equipment

3.1  Each pressure vessel which can be shut-off or every group of vessels with a shut-off device shall be equipped with a spring-loaded type approved safety valve which cannot be shut-off and which closes again reliably after blow-off.

Where a shut-off valve is installed between pressure vessel and safety valve, the shut-off valve has to be locked in open position.

Appliances for controlling pressure and temperature are no substitute for relief valves.

3.2  Safety valves shall be designed and set in such a way that the maximum allowable working pressure cannot be exceeded by more than 10 %. Means are to be provided to prevent the unauthorized alteration of the safety valve setting. Valve cones shall be capable of being lifted at all times.

3.3  Means of drainage which cannot be shut off are to be provided at the lowest point on the discharge side of safety valves for gases, steam and vapours. Facilities have to be provided for the safe disposal of hazardous gases, vapours or liquids discharging from safety valves. Heavy oil flowing out shall be drained off via an open funnel.

3.4  Steam-filled spaces are to be fitted with a safety valve if the steam pressure inside is liable to exceed the maximum allowable working pressure.

3.5  Heated spaces which can be shut-off on both the inlet and the outlet side are to be fitted with a safety valve which will prevent an inadmissible pressure increase should the contents of the space undergo dangerous thermal expansion or the heating elements fail.

Besides a temperature controller, electrically heated appliances are also to be equipped with a safety temperature limiter.
3.6 Pressure water tanks are to be fitted with a safety valve on the water side. A safety valve on the air side may be dispensed with if the air pressure supplied to the tank cannot exceed the maximum allowable working pressure.

3.7 Calorifiers are to be fitted with a safety valve at the cold water inlet.

3.8 Rupture discs are permitted only with the consent of GL in applications where their use is specially justified. They shall be so designed that the maximum allowable working pressure cannot be exceeded by more than 10%.

Rupture discs shall be provided with a guard to catch the fragments of the rupture element and have to be protected against damage from outside. The fragments of the rupture element shall not be capable of reducing the necessary section of the discharge aperture.

3.9 Pressure relief devices can be dispensed with in the case of accumulators in pneumatic and hydraulic control and regulating systems, provided that the pressure which can be supplied to these accumulators cannot exceed the maximum allowable working pressure and that the product of the pressure times the volume $PB \times I \leq 200$.

4. Liquid level indicators and feed equipment for heated pressure vessels

4.1 Heated pressure vessels in which a fall in the liquid level can result in unacceptably high temperatures in the vessel walls are to be fitted with a device for indicating the level of the liquid.

4.2 Pressure vessels with a fixed minimum liquid level shall be fitted with feed equipment of adequate size.

5. Sight glasses

Sight glasses in surfaces subject to pressure are allowed only if they are necessary for the operation of the plant and other means of observation cannot be provided. They shall not be larger than necessary and shall preferably be round. Sight glasses have to be protected against mechanical damage, e.g. by wire mesh. With combustible, explosive or poisonous media, sight glasses shall be fitted with closable covers.

6. Draining and venting

6.1 Pressure vessels and equipment shall be capable of being depressurized and completely emptied or drained. Particular attention is to be given to the adequate drainage facilities of compressed air vessels.

6.2 Suitable connections and a vent at the uppermost point shall be provided for the execution of hydraulic pressure tests.

7. Installation

7.1 When installing and fastening pressure vessels care is to be taken to ensure that the loads due to the content and the structural weight of the vessel and to movements and vibrations of the installation/unit cannot give rise to any excessive stress increases in the vessel’s surfaces. Where necessary, surfaces in the region of supports and brackets are to be fitted with reinforcing plates.

7.2 Pressure vessels and equipment are to be installed in such a way as to provide for maximum all-round visual inspection and to facilitate the execution of periodic tests. Where necessary, ladders or steps are to be fitted inside the vessels.

7.3 Wherever possible, horizontal compressed air receivers shall be installed in an inclined position. The angle of inclination shall be at least 10° (with the valve head at the top). Where vessels are installed athwartships of units, the angle shall be greater.

7.4 Where necessary, compressed air receivers are to be marked on the outside in a way that they can be installed in the position necessary for complete venting and drainage.

F. Tests

1. Non-destructive examination of welds

1.1 Non-destructive testing is to be performed according to the relevant rules.

1.2 Branch connections of class I and class II pressure vessels and heat exchangers, which are not suitable for radiographic examination, are to be tested by ultrasonics if the following three conditions are met:

- inner diameter of branch $\geq 120$ mm
- wall thickness of branch $\geq 15$ mm
- wall thickness of shell or head $\geq 30$ mm (including reinforcement pad if applicable)

1.3 Ultrasonic examinations are to be performed according to:

- GL Rules II – Materials and Welding, Part 3 – Welding, Chapter 2 – Design, Fabrication and Inspection of Welded Joints, Section 4
- AD Merkblätter, Sequence HP
- ASME Code, Section V
- British Standard BS 3923, Part 1
- DIN EN 583-1/2
- DIN EN 1712 to 1714
- AWS D 1.1 (American Welding Society)
2. Pressure tests

2.1 After completion, pressure vessels and equipment have to undergo constructional and hydrostatic tests. No permanent deformation of the walls may result from these tests.

During the hydrostatic test, the loads specified below may not be exceeded:

For materials with definite yield point:

$$\sigma_{zul} = \frac{R_{eH,20^\circ}}{1.1}$$

For materials without a definite yield point:

$$\sigma_{zul} = \frac{R_{m,20^\circ}}{2.0}$$

2.2 The test pressure $P_P$ for pressure vessels and equipment is generally 1.5 times the maximum allowable working pressure $P_B$, subject to a minimum of $P_B + 1$ bar.

In the case of pressure vessels and equipment which are only subjected to pressure below atmospheric, the test pressure shall at least match the working pressure. Alternatively a pressure test can be carried out with a pressure 2 bar in excess of atmospheric pressure.

2.3 All pressure vessels and equipment located in the fuel oil pressure lines of boiler firing equipment are to be tested on the oil side at a test pressure of 1.5 times the working pressure, subject to a minimum of 5 bar. On the steam side, the test is to be performed as specified in 2.2.

2.4 Pressure vessels in water supply systems which correspond to Standard DIN 4810 are to be tested at pressures of 5.2 bar, 7.8 bar or 13.0 bar as specified in the Standard.

2.5 Air coolers (e.g. supercharge air coolers) are to be tested on the water side at 1.5 times the maximum allowable working pressure, subject to a minimum of 4 bar.

2.6 Pressure tests with media other than water may be agreed to in special cases.

3. Tightness tests

For vessels and equipment containing dangerous substances (e.g. liquefied gases), GL reserve the right to call for a special gastightness test.

4. Testing after installation

Following installation, a check is to be carried out on the fittings of vessels and equipment and on the arrangement and settings of safety appliances. If necessary, an operating test is to be carried out.

G. Gas Cylinders

1. General

For the purposes of these Rules, gas cylinders are bottles with a capacity of not more than 150 l with an outside diameter of $\leq 420$ mm and a length of $\leq 2000$ mm which are charged with gases in special filling stations and are thereafter brought on the offshore unit/installation, where the pressurized gases are used. See also Section 10.

2. Design

The design of gas cylinders has to follow the Rules of recognized standards accepted by GL Head Office.

Attention should also be given to any relevant statutory requirement of the national Authority of the country in which the unit/installation is to be registered and/or of the country in whose territory it is to operate.
Section 12d

Gas and Oil Firing Equipment

A. General

1. Scope

The requirements of this Section are applicable to firing equipment of main and auxiliary boilers, hot/warm water generators, thermal oil heaters and inert gas generators.

Where oil burners are to be used additionally for burning waste oil and oil sludge, the necessary measures are to be agreed with the Head Office of Germanischer Lloyd in each case.

In addition, the following general requirements of this Section are mandatory for all installations and appliances.

2. Definitions

For the purpose of these Rules, the following definitions apply:

2.1 Fully automatic gas or oil burners

Fully automatic burners are burners equipped with automatic igniters, automatic flame monitors and automatic controls so that the ignition, flame monitoring and burner start-up and shutdown are effected as a function of the controlled variable without the intervention of operating personnel.

2.2 Semi-automatic gas or oil burners

Semi-automatic burners are burners equipped with automatic igniters, automatic flame monitors and automatic controls. Burner start-up is initiated manually. Shutdown may be initiated manually. Burner shutdown is not followed by automatic re-ignition.

2.3 Manually operated gas or oil burners

Manually operated burners are burners where every ignition sequence is initiated and carried through by hand. The burner is automatically monitored and shutdown by the flame monitor and, where required by the safety system, by limiters. Re-starting can only be carried out directly at the burner and by hand.

3. Documents for approval

3.1 A sectional drawing of each type of burner together with a description of its mode of operation, circuit diagrams and equipment lists of the electrical control system are to be submitted to GL in triplicate for approval.

3.2 Provided that they meet recognized standards, oil-fired burners up to 30 kg/h and gas-fired burners up to 120 kW are generally not subject to verification of drawings.

4. Approved fuels

4.1 As far as gaseous fuels are used, these Rules are applicable for gases with a relative density $\rho_r \leq 1.3$ (light gases).

Where gases with a relative density of $\rho_r > 1.3$ (heavy gases) and gases of unusual composition are burnt (e.g., hydrogen, gases containing hydrogen cyanide, etc.) deviating safety measures may be applied.

4.2 Regarding fuel for oil burners see Section 1, D.6.

5. Boiler equipment and burner arrangement

5.1 Burners are to be designed, fitted and adjusted in such a manner as to prevent flames from causing damage to the boiler surfaces or tubes which border the combustion space. Boiler parts which might otherwise suffer damage are to be protected by refractory lining.

The firing system shall be arranged as to prevent flames from blowing back into the boiler or engine room. Unburned fuel shall be safely drained.

5.2 Observation openings have to be provided at suitable points on the boiler or burner through which the ignition flame, the main flame and the lining can be observed.

5.3 Fuels leaking from potential leak points are to be safely collected in oil-tight trays and drained away.

6. Simultaneous operation of gas or oil firing equipment and internal combustion machinery

The operation of firing equipment in spaces containing other plants with a high air consumption, e.g., internal combustion engines or air compressors, shall not be impaired by variations in the air pressure.
B. Firing Equipment of Steam Boilers, Hot Water Heaters, Thermal Oil Heaters and Inert Gas Generators

1. General

1.1 Boilers, heaters and generators without constant and direct supervision are to be operated with automatic firing systems.

1.2 The facility is to be provided for manual operation (emergency operation). Flame monitoring shall remain operative even in manual operation.

1.3 Manual operation demands constant and direct supervision of the system.

1.4 Safety devices may only be bridged by means of a key-operated switch.

2. Preheating of fuel oil

2.1 Fuel oil preheating equipment shall enable the steam boilers, hot water heaters or thermal oil heaters to be started up with the facilities available on board.

2.2 Any controllable heat source may be used to preheat the fuel oil. Preheating with open flame is not permitted.

2.3 Fuel oil circulating lines are to be provided to enable the preheating of the fuel oil prior to the start-up of the boilers or heaters.

   Where only steam-operated preheaters are provided, fuel which does not require preheating shall be available to start up the boilers or heaters.

   When a change is made from heavy to light oil, the light oil may not be passed through the heater or be excessively heated.

2.4 The preheating temperature is to be selected so as to avoid excessive foaming, the formation of vapour or gas and also the formation of deposits on the heating surface.

   Where fuel oil is preheated in tanks at atmospheric pressure, the requirements in Section 13a, C.5. are to be complied with.

   The design and construction of pressurized fuel oil heaters are subject to the requirements in Section 12c - Pressure Vessels, Heat Exchangers and Filters.

2.5 Temperature or viscosity control has to be done automatically. For monitoring purposes, a thermometer or viscosimeter is to be fitted to the fuel oil pressure line in front of the burners.

2.6 Should the oil temperature or viscosity deviate above or below the permitted limits, an alarm system shall signal this fact to the boiler operating platform.

3. Pumps, pipes, valves and fittings

3.1 By means of a hand-operated quick-closing device mounted at the fuel oil manifold or outside the immediate place of installation in case of gaseous fuels, it shall be possible to isolate the fuel supply to the burners from the pressurized fuel lines. Depending on design and method of operation, a quick-closing device may also be required directly in front of each burner.

3.2 Gas supply system

A gas pressure regulator shall be installed in the connecting line of each gas fired burner so that a uniform flow pressure will be achieved.

The gas pressure regulators shall be equipped with a safety device which automatically prevents the part downstream of the gas firing installation from being exposed to an inadmissibly high pressure in the case of failure of the gas pressure regulator.

The safety device downstream the gas pressure regulator is not required if this part of the system is rated for the highest possible gas pressure.

3.3 For further details see Section 13b.

4. Safety equipment

4.1 The correct sequence of safety functions when the burner is started up or shut down is to be ensured by means of a burner control box.

4.2 Two automatic shut-off devices shall be provided at the fuel supply line to the burner.

In case of gaseous fuels a venting line shall be provided between the two automatic shut-off devices, which opens safely when the gas fuel supply is shut-off (block and bleed).

For the fuel oil supply line to the ignition burner one automatic shut-off device will be sufficient, if the fuel oil pump is switched off after ignition of the burner.

4.3 In an emergency it shall be possible to close the automatic shut-off devices from the boiler control platform and – where applicable – from the control room.
The automatic shut off device shall not release the fuel supply to the burner during start up and shall interrupt the fuel supply during operation (automatic restart possible) if one of the following faults occur:

a) Atomizer:
   − failure of the required pressure of the atomizing medium (steam and compressed-air atomizers)
   − failure of the fuel pressure needed for atomization (pressure atomizers)
   − insufficient rotary speed of spinning cup or primary air pressure too low (rotary atomizers)

b) failure of combustion air supply
c) failure of control power supply
d) failure of induced-draught fan or insufficient opening of exhaust gas register
e) burner retracted or pivoted out of position
f) for gaseous fuels:
   − supply pressure below the minimum value upstream the pressure reducer
   − inadmissible high gas consumption due to high gas pressure

The fuel supply shall be interrupted by closing the automatic shut off devices and interlocked by means of the burner control box if

a) a flame does not develop within the safety period following start-up (cf. 5.8)
b) the flame is extinguished during operation and attempt to restart the burner within the safety period is unsuccessful (cf. 5.8), or
c) limit switches are actuated.

The return line of burners with return lines shall also be provided with an automatic shut off device. The shut off device in the return line may be dispensed with if the return line is not under pressure and no oil is able to flow back when the burner is shut-down.

Firing equipment with electrically operated components shall also be capable of being shut-down by an emergency switch located outside the space in which the equipment is installed. In analogous manner, means shall be provided for a remote shut-down of steam-operated fuel oil service pumps.

The suitability of safety and monitoring devices (e.g. burner control box, flame monitoring device, automatic shut off device and limiters) for marine use is to be proven by type testing.

5. Design and construction of burners

5.1 The type and design of the burner and its atomizing and air turbulence equipment shall ensure virtually complete combustion.

5.2 Burners shall be designed and constructed so that personnel cannot be endangered by moving parts. This applies particularly to blower intake openings. The latter shall also be protected to prevent the entry of droplets of water.

5.3 The high-voltage ignition system shall be automatically disconnected when the burner is retracted or pivoted out of the operating position. A catch is to be provided to hold the burner in the swung out position.

5.4 Steam atomizers shall be fitted with appliances to prevent fuel oil entering the steam system.

5.5 Where dampers or similar devices are fitted in the air supply duct, care shall be taken to ensure that air for purging the combustion chamber is always available unless the fuel supply is necessarily interrupted.

5.6 Where an installation comprises several burners supplied with combustion air by a common fan, each burner shall be fitted with a shut-off device (e.g. a flap). Means shall be provided for retaining the shut-off device in position, and its position shall be indicated.

5.7 Every burner shall be equipped with an igniter. The ignition is to be initiated immediately after purging. In the case of low-capacity burners of monobloc type (permanently coupled oil pump and fan) ignition may begin with start-up of the burner unless the latter is located in the roof of the chamber.

5.8 Every burner is to be equipped with a safety device for flame monitoring. This appliance shall comply with the following safety periods on burner start-up or when the flame is extinguished in operation. The safety period is the maximum permitted time during which fuel may be supplied to the combustion space in the absence of a flame:

   − on start-up: 5 seconds for oil fired burners resp. 2 seconds for gas fired burners
   − in operation: 1 second

Where this is justified, longer safety periods may be permitted for gas burners with a power of up to 120 kW and oil burners with an oil throughput of up to 30 kg/h.

Measures shall be taken to ensure that the safety period for the main flame is not prolonged by the action of the igniter (e.g. pilot burners).
5.9 Where burners are blown through after shut-down, provision shall be made for the safe ignition of the residual oil ejected.

6. Purging of combustion chamber and flues, exhaust gas ducting

6.1 The combustion chamber and flues are to be adequately purged with air prior to every burner start-up. A warning sign is to be mounted to this effect.

6.2 A threefold renewal of the total air volume of the combustion chamber and the flue gas ducts up to the funnel inlet is considered sufficient. Normally purging shall be performed with the total flow of combustion air for at least 15 seconds. It shall, however, in any case be performed with at least 50 % of the volume of combustion air needed for the maximum heating power of the firing system.

6.3 Bends and dead corners in the exhaust gas ducts are to be avoided.

Dampers in uptakes and funnels should be avoided. Any damper which may be fitted shall be so installed that no fuel supply is possible when the cross-section of the purge line is reduced below a certain minimum value. The position of the damper shall be indicated at the boiler control platform.

6.4 Where an induced-draught fan is fitted, an interlocking system shall prevent start-up of the firing equipment before the fan has started. A corresponding interlocking system is also to be provided for any flaps which may be fitted to the funnel opening.

7. Electrical equipment

Electrical controls, safety appliances and their types of enclosure shall comply with the provisions of Section 16 – Control Systems, Instrumentation and Chapter 6 - Electrical Installations.

8. Testing

8.1 The installation is to be subjected to operational tests including, in particular, determination of the purging time required prior to burner start-up. Satisfactory combustion at all load settings and the reliable operation of the safety equipment are to be checked.

8.2 After installation, the pressurized fuel oil system is to be subjected to a pressure and tightness test; see Section 13d, C.4.

C. Firing Equipment for Warm Water Heaters and Fired Heaters

1. Atomizing burners

1.1 Fully and semi-automatic atomizing burners shall meet the requirements of DIN 4787/EN 267 or shall be recognized as equivalent. Adequate purging by means of a fan shall be ensured prior to each ignition effected by the controls. In general, a purging period of at least 5 seconds may be deemed sufficient. Where the flue gas ducting is unfavourable, the purging time is to be extended accordingly.

1.2 Electrical equipment items and their types of enclosure shall comply with the requirements in Chapter 6 – Electrical Installations. High-voltage igniters shall be adequately protected against unauthorized interference.

1.3 Where dampers or similar devices are mounted in the air supply line, care shall be taken to ensure that air is available in all circumstances for purging the combustion space.

1.4 Pivoted burners may be swivelled out only after the fuel supply has been cut off. The high-voltage ignition equipment shall likewise be disconnected when this happens.

1.5 The plant shall also be capable of being shut down by means of an emergency switch located outside the space in which the plant is installed.
Section 13a

Storage Tanks for Liquid Fuels, Hydraulic and Thermal Oils

A. General Safety Precautions for Liquid Fuels

Tanks and fuel pipes shall be so located and equipped that fuel cannot spread either inside the installation/unit or on deck and cannot be ignited by hot surfaces or electrical equipment. Tanks shall be fitted with vents and overflow pipes to prevent excessive pressure.

B. Distribution, Location and Capacity of Fuel Tanks

1. Arrangement of fuel tanks

1.1 The fuel supply shall be stored in several tanks so that, even in the event of damage of the bottom of one of the tanks, the fuel supply will not be entirely lost.

1.2 Provision shall be made to ensure that internal combustion engines and boiler plants operating on heavy oil can operate temporarily on fuel which does not need to be preheated. Appropriate tanks shall be provided for this purpose.

1.3 Fuel tanks shall be separated by cofferdams from tanks containing lubricating, hydraulic, thermal or edible oil, as well as from tanks containing boiler feedwater, condensate or drinking water. This does not apply to used lubricating oil which will not be used on board anymore.

1.4 Fuel oil tanks adjacent to lubricating oil circulating tanks are to be provided with suitable means, e.g. level alarms safeguarding that the maximum level in the fuel oil tanks will not exceed the lowest operation level in the lubricating oil circulating tanks.

2. Location of fuel tanks

2.1 Fuel tanks may be located above engines, boilers, turbines and other equipment with a high surface temperature (above 220 °C) only if adequate spill trays are provided below such tanks and they are protected against heat radiation.

Surface temperature of the elements without insulation and lagging will be considered.

2.2 A special fuel supply shall be provided for the prime movers of the emergency source of electrical power.

The fuel supply shall be sufficient for at least 18 hours operation.

By the arrangement and/or heating of the fuel tank the emergency diesel equipment shall be kept in a state of readiness even when the outside temperature is low.

C. Fuel Tank Fittings and Mountings

1. For fuel filling and suction lines see Section 13e, D.; for air, overflow and sounding pipes, see Section 13e, K.:

2. Fuel service tanks shall be so arranged that water and residues can settle out.

Fuel tanks shall be fitted with water drains with self-closing shut-off valves.

3. Tank gauges

3.1 The following tank gauges are permitted:

- sounding pipes
- oil level indicating devices
- oil level gauges with flat glasses and self-closing shut-off valves at the connections to the tank and protected against external damage.

3.2 For fuel storage tanks the provision of sounding pipes is sufficient. Such sounding pipes need not be fitted to tanks equipped with oil level indicating devices which have been type-tested by GL.

3.3 Fuel service tanks shall be fitted with oil level indicating devices or oil-level gauges according to 3.1.

3.4 Sight glasses and oil gauges fitted directly on the side of the tank and cylindrical glass oil gauges are not permitted.

3.5 Sounding pipes of fuel tanks may not terminate in accommodation spaces, nor shall they terminate in spaces where the risk of ignition of spillage from the sounding pipes might arise.
3.6 Sounding pipes should terminate outside machinery spaces. Where this is not possible, the following requirements are to be met:

- Oil-level gauges are to be provided in addition to the sounding pipes.
- Sounding pipes are either to terminate in locations remote from ignition hazards or they are to be effectively screened to prevent that spillage may come into contact with the source of ignition.
- The sounding pipes are to be fitted with self-closing shut-off devices and self-closing test cocks.

4. Attachment of mountings and fittings to fuel tanks

4.1 Appliances, mountings and fittings not forming part of the fuel tank equipment may be fitted to tank walls only by means of intermediate supports. Only components forming part of the tank equipment may be fitted to free-standing tanks.

4.2 Valves and pipe connections shall be attached to reinforcement flanges welded to the tank walls. Holes for stud bolts are not be drilled in the tank walls.

Instead of reinforcement flanges, short, thick walled pipe stubs with flange connections may be welded to the tank walls.

5. Tank heating system

5.1 Tanks for viscous fuels shall be provided with a heating system; it shall be possible to control the heating of the individual tank.

Heating coils shall be appropriately subdivided or arranged in groups with their own shut-off valves.

Where necessary, suction pipes shall be provided with a heating arrangement.

5.2 Oil in storage tanks is not to be heated to temperatures within 10 °C below the flash point of the fuel oil, except that where fuel in service tanks, settling tanks and any other tanks in supply systems is heated, the following arrangements are to be provided:

- The length of the vent pipes from such tanks and/or 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 sources of ignition.
- Air pipe heads 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 above such fuel tanks, except for vented cofferdams.

5.3 For units with ice class the tank heating is to be so designed that the fuel oil remains capable of being pumped under all ambient conditions.

5.4 At the tank outlet, heating coils shall be fitted with means of closing. Steam heating coils are to be provided with means for testing the condensate for oil between tank outlet and closing device. Heating coil connections in tanks shall normally be welded. The provision of detachable connections is permitted only in exceptional cases.

Inside tanks, heating coils shall be supported in such a way that they cannot be subjected to impermissible stresses due to vibration, particularly at their points of clamping.

5.5 Tanks for fuel which requires preheating shall be fitted with thermometers and, where necessary, with thermal insulation.

5.6 For tank scantlings see the GL Rules I – Ship Technology, Part 1 - Seagoing Ships, Chapter 1 - Hull Structures.

6. Hydrostatic pressure tests

Fuel tanks shall be tested for tightness according to the requirements defined in G.

D. Lubricating, Hydraulic and Thermal Oils

1. Oil drain tanks shall be sufficiently large to ensure that the residence time of the oil is long enough for the expulsion of air bubbles, the settling out of residues, etc. The tanks shall be large enough to hold at least the oil contained in the entire circulation systems, including the contents of gravity tanks. The safety margin shall be 15 %.

2. Measures, such as the provision of baffles or limber holes consistent with structural strength requirements, particularly relating to the machinery bed plate, shall be taken to ensure that the entire contents of the tank remain in circulation. Limber holes shall be located as near to the bottom of the tank as possible. Lubricating oil drain pipes from the engine to the drain tank shall be submerged at their outlet ends. Suction pipe connections shall be placed as far as is practicable from the oil drain pipe, so that neither air nor sludge can be sucked up irrespective of the inclination of the unit.

3. Oil drain tanks shall be equipped with sufficiently dimensioned vents.
E. Storage of Oil Residues

1. Tank heating system
To ensure the pumpability of the oil residues a tank heating system in accordance with C.5. is to be provided, if considered necessary.

Sludge tanks are generally to be fitted with means of heating which are to be so designed that the content of the sludge tank may be heated up to 60 °C.

2. Sludge tanks

2.1 Capacity of sludge tanks
The capacity of sludge tanks shall be such that they are able to hold the residues arising from the operation of the installation/unit having regard to the maximum duration between offshore supply services. ¹

2.2 Fittings and mountings of sludge tanks

2.2.1 For tank sounding devices C.3.2 and C.3.5 are to be applied.

2.2.2 For air pipes, see Section 13e, K.

F. Storage of Gas Bottles for Domestic Purposes

1. Storage of gas bottles shall be located on open deck or in well ventilated spaces which only open to the open deck.

2. Gaseous fuel systems for domestic purposes shall comply with an acceptable standard. ¹

G. Testing for Tightness

1. Testing of tanks for fuel oil, lubricating, hydraulic and thermal oil as well for water is to be effected by a combination of a leak test by means of air pressure and an operational test by means of water or the liquid for which the tank is intended to be used.

The air pressure is not to exceed 0,2 bar gauge. The increased risk of accident while the tanks are subjected to the air pressure is to be observed.

Butt welds made by approved automatic or semi-automatic processes on erection welds need not be tested, provided that these welds are carefully visually examined and are free of repairs. The results of the non-destructive examinations made at random to the satisfaction of the GL Surveyor shall not reveal significant defects. If there is evidence from inspection results that the quality of these welds has been downgraded significantly, the extent of the leak testing may be increased to the GL Surveyor's discretion.

2. Where one tank boundary is formed by the unit's shell, the leak test is to be carried out before launching. For all other tanks leak testing may be carried out after launching. Erection welds as well as welds of assembly openings are to be coated ² after the leak test is carried out. This applies also to manual weld connections of bulkheads with the other tank boundaries and of collaring arrangements at intersections of tank boundaries and e.g. frames, beams, girders, pipes, etc. If it is ensured that in adjacent tanks the same type of liquid is carried, e.g. in adjacent ballast tanks, the above mentioned weld connections may be coated ² prior to the leak test.

All other welded connections in tank boundaries may be coated prior to the leak test if it is ensured by suitable means (e.g. by visual examination of the welded connections) that the connections are completely welded and the surfaces of the welds do not exhibit cracks or pores.

3. Where the tanks are not subjected to the leak test as per 2, but are leak tested with water the bulkheads are, in general, to be tested from one side. The testing should be carried out prior to launching or in the dock. Subject to approval by GL, the test may also be carried out after launching. Water testing may be carried out after application of a coating ², provided that during the visual inspection as per 2. above deficiencies are not noted. The test head shall correspond to a head of water of 2,5 m above the top of tank or to the top of overflow or air pipe, whichever is the greater.

4. The operational test may be carried out when the unit is afloat or during the trial trip. For all tanks the proper functioning of filling and suction lines and of the valves as well as functioning and tightness of the vent, sounding and overflow pipes is to be tested.

¹ National requirements, if any, are to be observed.

² Shop primers are not regarded as a coating within the scope of these requirements.
Section 13b

Rotary Pumps and Compressors

A. General

1. Scope
This Section covers minimum requirements and regulations for rotary pumps and compressors regarding their design, construction and testing. The rules for compressors may be applied also for fans accordingly.

The requirements for reciprocating compressors of the normal marine types are defined in the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 2, M.

2. Definitions

2.1 Pumps
For the purpose of these Rules liquid pumps include:
− centrifugal pumps
− side channel pumps
− rotary pumps

For pumps of other designs, e.g. liquid ejectors, the requirements listed in this Chapter may apply accordingly but have to be agreed with Germanischer Lloyd for application.

2.2 Compressors
For the purpose of these Rules compressors are machines with rotary impellers for the delivery and compression of gases irrespective of pressure increase.

B. Design and Construction

1. Common design requirements
1.1 The design of pumps and compressors shall be performed in accordance with applicable service conditions as well as additional operating and environmental conditions.

1.2 The design of relevant pump and compressor drives shall be in accordance with recognised international technical standards and shall ensure a satisfactory operation. The rated output of the drive is to be determined in such a way as to ensure the reliable operation of the pump/compressor. It is required to be compatible with the mode of operation and characteristic curve of the pump/compressor and with the properties of the flowing media.

1.3 The design of pipe connections shall ensure that no impermissible forces and moments will be transmitted to the pump and compressor casing.

1.4 Pumps and compressors have to be equipped with adequate dampening devices to minimize vibrations.

2. Specific design requirements for pumps

2.1 Centrifugal pumps have to be designed so that they can be operated for a short time without damage even when the discharge line is closed.

2.2 Positive displacement pumps shall be protected against excessive pressure increases in the pump casing by fitting relief valves which cannot be adjusted to the closed position.

2.3 The shaft sealing of circulating pumps for thermal oil systems shall be so designed that oil leakage cannot occur in an unacceptable manner and with unacceptable leakage rates.

2.4 Pumps shall be designed to avoid any cavitation which may occur during pump operation and which may lead to any damage and failure.

3. Specific design requirements for compressors

3.1 Compressors shall be designed and equipped with surge relief valves preventing surges.

3.2 Surge relief valves shall meet the following requirements:
− fast stroking speed when opening
− high capacity (Twice the minimum flow capacity is required simply for stable operation under full recycle condition, as in start up and shut down.)
− noise abatement provisions
− high performance throttling control

3.3 All major parts of the rotating equipment, such as shaft, impellers and bladed wheels shall be dynamically balanced to avoid vibrations.

3.4 Design and construction of compressor piping systems are outlined in Section 13e - Piping Systems for Specific Services.
3.5 If pressure containing equipment, such as pressure vessels or heat exchangers, will be part of the complete compressor unit, these items will have to be designed acc. to an international standard and shall further meet the requirements of Section 12c. The additional technical documentation will have to be provided to GL for approval.

4. Design documentation

4.1 Design documentation for pumps

4.1.1 The following design documentation for pumps shall be submitted for approval upon request by GL:

- general assembly drawing and additional sectional drawings showing all pump parts and additional equipment necessary for operation
- detail drawings of rotors, impellers, casings, valves, bed frames with additional parts lists
- pump data sheet showing all technical performance data
- data sheets showing characteristic curves of pump
- material Certificates for pump casing, shaft and other parts which are in contact with flowing media
- data sheets about pump drive
- Factory Acceptance Test (FAT) and Factory Performance Test (FPT) Reports, if available. The FAT/FPT Reports have to show all pump and compressor performance data specified by the client acc. to specifications and additional related technical codes.

Special approval of the above documentation shall be given to pumps used for handling of liquefied gases and dangerous or toxic chemicals.

4.2 Design documentation for compressors

4.2.1 The following design documentation for compressors shall be submitted for approval upon request by GL:

- compressor specification with maximum operating conditions
- general assembly drawing of complete compressor unit including drive, base frame and all additional equipment
- detail drawings of rotors, impellers, casings, valves, bed frames with additional parts lists
- detailed descriptions of control and safety system and anti surge system
- arrangement drawings and flow diagram of the lubrication system
- drawings, technical documentation and data sheets about compressor drive
- material specifications and material Certificates for compressor casing, rotating parts (shaft, wheel, blades)
- welding specification, welding procedures
- dynamic and high speed balancing records of rotating parts
- mechanical running test records showing all required data of the technical performance of the compressor
- vibration and noise measurement records
- operating and instruction manual

Special proof of the above documentation shall be given to compressors used for starting air, control air systems and for dangerous and/or toxic gases, e.g. sour gas.

C. Materials

1. The material used for the construction of compressor and pump systems including all additional components shall be selected suitable to the applicable service conditions.

2. Materials shall be resistant to internal corrosion and erosion, so far as applicable and required. The materials have to comply with GL Rules II – Materials and Welding.

Materials not included in the GL Rules II – Materials and Welding shall be agreed by GL upon request.

3. Materials for Pumps and compressors for sour oil and sour gas service have to comply with the requirements of Section 15.

4. Material testing

The tests have to comply with GL Rules II – Materials and Welding, Part 1 – Metallic Materials, Chapter I – Principles and Test Procedures, Section 1, H. For components exposed to pressure GL Material Certificates and for all other parts Manufacturer Test Reports are to be issued.

4.1 Pumps

The following parts of the pumps are subject to testing:

- pump casing
- rotating parts, such as rotors, disks, shafts, shrink rings and other dynamically loaded components
4.2 Compressors

The following parts of the compressors are subject to testing:
- compressor casing
- shaft
- impeller/rotor materials
- main casing bolting

Drive and gear box:
- shaft, wheel, pinions
- main drive couplings

Seal gas system:
- pressure containing components
- auxiliary pressure containing fluid piping

Auxiliary pressure containing equipment:
- pressure vessels, heat exchangers
- surge relief valves: Material Certificates for valve body, valve bonnet, valve trim

Detailed requirements for scope of tests shall be agreed with GL.

D. Testing

1. Pump testing

1.1 General

Pumps shall be tested with state-of-the-art test equipment. All test facilities shall be calibrated prior to start of any test. The performance test and test procedure shall be carried out according to an international recognized standard, e.g. ISO 9906.

The pump manufacturer shall provide the pump inspection and test procedure prior to testing for consultation and approval by GL.

1.2 Pressure test

All pump components exposed to internal pressure (casing, cover, seal plate) are to be subjected to a hydrostatic pressure test. The following test pressures shall apply:

\[ p_p = 1.5 \times p_{e,all} \text{ where } p_{e,all} \leq 200 \text{ bar} \]

subject to a minimum of \( p_p = 4 \text{ bar} \)

\[ p_p = p_{e,all} + 100 \text{ bar where } p_{e,all} > 200 \text{ bar} \]

\[ p_p = \text{test pressure [bar]} \]

\[ p_{e,all} = \text{maximum allowable working pressure [bar]} \]

1.3 Pump performance test

1.3.1 For the pumps listed below, a performance test (Factory Performance Test) shall be carried out in the manufacturer’s works in presence of a GL Surveyor:
- crude oil transfer pumps
- water injection pumps
- mud pumps, if not manufactured in an API licensed factory
- bilge pumps
- ballast pumps
- sea cooling water pumps
- fresh cooling water pumps
- fire water pumps
- emergency fire water pumps including drive units
- condensate pumps
- boiler feedwater pumps
- boiler circulating pumps
- lubricating oil pumps
- fuel booster and transfer pumps
- circulating pumps for thermal oil installations

1.3.2 Pump performance data

The performance test shall show the contractually specified data, among which usually are:

- volume flow rate \( Q \text{ [m}^3\text{/h]} \)
- pump power input \( P \text{ [KW]} \)
- speed of rotation \( n \text{ [1/min]} \)
- delivery head \( H \text{ [m]} \)

The volume flow rate is the flow rate which is discharged on the delivery side of the pump.

1.4 Translation / conversion of test results

For centrifugal pumps the test speed may be carried out within a range of 50% to 120% of the nominal speed \( n_N \).

In order to convert the performance data \( Q, H \) and \( P \) measured at test speed \( n \text{ [1/min]} \) to the corresponding values for the nominal speed \( n_N \text{ [1/min]} \) the following equations shall apply:

\[ Q_N = Q \cdot \frac{n_N}{n} \]

\[ H_N = H \cdot \left( \frac{n_N}{n} \right)^2 \]

\[ P_N = P \cdot \left( \frac{n_N}{n} \right)^3 \]

For positive displacement pumps the permissible deviations shall be agreed between Owner/Operator and GL depending on the design, service and operating requirements of the pump.

Conversion of the measured power input \( P \) to the nominal power input \( P_N \) is also required where the power input is measured with a liquid which differs in
regards to its density and/or viscosity from the liquid specified in the contract.

1.5 NPSH value
In case of required verification of the NPSH value (Net Positive Suction Head), an equation is to be agreed between the Owner/Operator and the pump supplier to enable the conversion to be made, if the test speed differs from the nominal speed.

1.6 Relief valve setting
On positive displacement pumps the setting of the relief valve is to be checked. If a positive displacement pump is supplied without a relief valve this is to be noted in the test Certificate.

1.7 Smooth running
During the performance test the pump is to be checked for smooth running and bearing temperature.

1.8 Alignment
If the performance test is carried out on the entire unit comprising the pump, coupling, drive and common base plate, the alignment of the unit is to be checked. Tests performed on the entire unit shall be noted in the test Certificate.

1.9 Test records
All measurements and test results shall be recorded during pump performance test and shall be reviewed and approved by GL.

2. Compressor testing
2.1 General
The compressor manufacturer shall provide a detailed inspection and test procedure which shall include all scheduled tests for the compressor and additional components. The scope of tests within the test procedure shall be agreed by GL.

The compressors shall be tested with state-of-the-art test equipment. All test facilities shall be calibrated prior to start of any test. The compressor test shall be carried out according to a recognized international standard and shall include the following tests:

2.2 Hydrostatic casing tests
The compressor casing and other pressure containing parts shall be subject to a hydrostatic test pressure which shall be 1,5 times the maximum allowable working pressure.

The hydrostatic pressure test shall be carried out for a sufficient time period, e.g. 30 minutes, to enable satisfactory inspections and examinations of all parts under pressure.

2.3 Over speed tests
Unless agreed otherwise, wheels and impellers (including spare rotor impellers) shall be overspeed tested with a minimum speed of 10% above the maximum permissible speed at maximum permissible working temperature. The duration shall be not less than one minute.

All test speeds and measurements shall be recorded and submitted for GL review.

Critical impeller dimensions such as bore and outside diameter shall be measured before and after overspeed test.

2.4 Frequency and vibration tests
If a frequency and vibration test will be required due to the compressor operation requirements, this test shall be carried out according to a recognized international standard and according to the manufacturer’s test procedure approved by GL. If a vibration analysis has been carried out, the test results shall be considered for final approval of the compressor performance.

2.5 Balancing
Each shaft, impeller and bladed wheel as well as the complete rotating assembly has to be dynamically balanced and tested in accordance with the approved test procedure. For assessment of the balancing conditions the standard DIN ISO 1940 or equivalent regulations may apply.

2.6 Noise measurement (optional)
If a noise measurement will be required and specified, the noise measurement will have to be carried out acc. to a recognized international standard. The noise measurements shall be reviewed by GL and shall be verified for the performance and acceptance of the compressor.

2.7 Mechanical running/ performance test
The mechanical running/performance test shall be performed with the completely assembled compressor unit including all parts, seals and auxiliary systems such as lubrication system as per compressor specification. This test shall be performed according to an international recognized standard and the manufacturer’s test procedure to be agreed by GL. During this test the following steps shall be performed:

− check of control panel, control and automation units including instrumentation, cables and electrical equipment applicable for compressor operation
− check of lube oil system, oil pressures, oil flow rates and temperatures as per compressor operating requirements
− check of compressor hydraulic system
− check of compressor connections for leakage
− test of all other auxiliary systems
− check and test of surge relief valves
− noise measurement results and records (optional)
check of compressor performance data, compressor characteristic curves as per compressor specification

The mechanical running test shall be witnessed by a GL Surveyor. During mechanical running test all test results and measurements have to be recorded.

2.8 Test records
All measurements and test results shall be recorded during compressor performance test and shall be reviewed and approved by GL.
Section 13c

Valves

A. General

1. Scope
This Section defines requirements for the following types of valves:

1.1 Process control and shut-off valves, see B, and additional specific requirements for steam service, see C, and LNG service, see D.

1.2 Safety valves, see F, and additional specific requirements for their application to steam and boiler services, see G, and Liquefied Natural Gas (LNG) services, see H.

1.3 Quick Connect/Disconnect Couplings (QC/DC) are summarized in E.

2. Other Rules and regulations
The following GL Rules will apply additionally:

I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 - Machinery Installations
II - Materials and Welding
VI – Additional Rules and Guidelines, Part 7 - Guidelines for the Performance of Type Tests, Chapter 8 – Test Requirements for Components and Systems of Machinery Installations and Offshore Technology

B. General Requirements for Process Control and Shut-off Valves

1. General

1.1 Scope
Valves for on- and offshore process applications shall be designed acc. to operating and service conditions as well as environmental conditions required and specified for a unit/installation.

The design and sizing has to take the most severe process service and operating condition into consideration.

1.2 Definitions

1.2.1 Design pressure
The design pressure is at least the maximum allowable working pressure that the valve will be subjected to during its operation within a piping system or process plant.

1.2.2 Design temperature
The design temperature "t" is at least the maximum allowable temperature of the internal fluid, but not less than + 50 °C. If low temperature conditions are expected during winter operation, by gas expansion chilling or other reasons, a minimum temperature limit "tmin" has to be defined in addition to "t".

1.2.3 Flowing media
The flowing media through a valve may be gas, steam or liquid. In some process applications two phase flow has to be considered.

1.2.4 Flow characteristics
The flow characteristic is the relationship between the flow of the fluid through the valve and the additional related valve stem travel from 0 to 100 %.

Depending on the design of the internal parts of the valve (valve trim) used for flow control, the flow characteristic may be of linear, equal percent, quick opening or on-off type.

1.2.5 Valve trim
The valve trim is defined as the internal parts of a valve which modulate the flow of the flowing media.

2. Design

2.1 General

Valves and all associated pressure retaining parts shall be state-of-the-art design and shall be designed according to recognized international technical standards.

2.1.1 Valves shall be designed according to the process service and operating conditions as well as the environmental conditions required and specified for the specific valve application. The design shall consider the most severe process and operating conditions.

2.1.2 Valves designed for hydrocarbon services shall comply with internationally accepted petroleum industry specifications and pressure ratings, e.g. API/ANSI. Flange connections are to be standardized acc. to the specific design code.
2.1.3 Pressure-temperature ratings applicable for valve design shall be in accordance with recognized international standards.

2.1.4 Screwed-on valve bonnets shall normally not be used for valves with nominal diameter exceeding 40 mm in Class I piping systems and for valves on vessels. Valves with screw-on bonnet design in flammable and/or toxic media service conditions are not permitted.

2.1.5 Screwed-on valve bonnets shall be secured against loosening when the valve is operated.

2.1.6 Valve packing shall be designed to avoid any leakage which may cause danger and risk to people and environment as well as to additional plant sections and machinery. Valve packing shall be designed of pliable seal material with satisfactory alignment of the valve stem within the valve bonnet and shall provide constant packing stress.

2.1.7 For flammable and/or toxic media service bellow seal bonnets shall be used where applicable.

2.1.8 Valves operated by hand wheel shall normally be closed by turning the hand wheel clockwise.

2.1.9 All valve types shall be equipped with position indicators which may be integrated in valve positioners or digital valve controllers where applicable. Indicators shall be provided to show the open and closed position of the valve, unless this can be observed in some other way, e.g. by a distinctly rising valve stem.

2.1.10 Welded necks of valve bodies shall be sufficiently long to ensure that the valves are not distorted as result of welding and subsequent heat treatment of the joints.

2.1.11 Valves for steam service shall meet the additional requirements listed in C.

2.1.12 Documentation
Documents to be submitted for approval upon request by GL:
- Valve data sheet showing service and operating conditions including valve type and size.
- General assembly drawing of valve and actuator including all mounted accessories and detailed parts list.
- Design drawings of pressurized parts and which are in contact with media (e.g. valve body, bonnet, trim) including parts list showing used materials.
- Design calculations, sizing calculations for flow service and actuator layout.
- For welded valve design: Welding documentation (Welding Procedure Specification, Procedure Qualification Record, Welding Plan, heat treatment charts, NDE records, etc.).
- Material Certificates of valve body and bonnet. For sour gas service material Certificates for valve trim shall be additionally provided. The material traceability of valve body, bonnet and trim as well as allocation of relevant material Certificates (e.g. through the valve serial number) shall be ensured by the valve manufacturer.
- Valve accessories which are in contact with flowing media, e.g. outlet silencer for noise reduction of a surge relief valve.
- Leakage Test Certificate, if applicable
- Pressure Test Certificate, if applicable

3. Materials
The selection and use of valve materials shall be based on the design pressure and design temperature conditions in conjunction with corrosive and erosive properties of the flowing media and the environmental conditions.

3.1 Materials for valve bodies for non corrosive (hydrocarbon) services shall comply with GL Rules, Part II - Materials and Welding.

3.2 For corrosive hydrocarbon service the materials as in 3.1 are acceptable, yet corrosion resistant materials are required for internal trim, i.e. stainless steels, austenitic stainless steels or higher alloys.

3.3 Special consideration for valve body, bonnet and internal trim shall be given in cases of media containing chloride (danger of chloride stress cracking) or containing sour gas (danger of hydrogen sulphide cracking).

3.4 Other materials to be used for valve design and construction which are not included in GL Rules II – Materials and Welding shall be subject to approval by Germanischer Lloyd.

3.5 Valve materials for sour gas service shall comply with NACE MR 01-75, see also Section 15.

4. Valve testing

4.1 Hydrostatic pressure tests

4.1.1 All valves shall be subjected at the manufacturer’s workshop to a hydrostatic test in accordance with the applicable valve design code. The hydrostatic test pressure shall not be less than 1,5 times the design pressure.
Table 13c.1  Approved materials

<table>
<thead>
<tr>
<th>Material and product form</th>
<th>Limits of application</th>
<th>Material grades in according with the Rules for Classification and Construction II – Materials and Welding, Part 1 – Metallic Materials, Chapter 1 - 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel plates and steel strips</td>
<td>–</td>
<td>Plates and strips of high-temperature steels to Chapter 2, Section 1, E.</td>
</tr>
<tr>
<td>Steel pipes</td>
<td>–</td>
<td>Seamless and welded pipes and ferritic steels Chapter 2, Section 2, B. and C.</td>
</tr>
<tr>
<td>Forgings and formed parts: a) drums, headers and similar hollow components without longitudinal seam b) covers, flanges, nozzles, end plates</td>
<td>–</td>
<td>Forgings for boilers, vessels and pipelines Chapter 2, Section 3, E. Formed and pressed parts to Chapter 2, Section 6, A. and B.</td>
</tr>
<tr>
<td>Nuts and bolts</td>
<td>≤ 300°C ≤ 40 bar ≤ M 30</td>
<td>DIN 267, Parts 3 and 4 or equivalent standards</td>
</tr>
<tr>
<td>Steel cast iron</td>
<td>–</td>
<td>Cast steel for boilers, pressure vessels and pipelines to Chapter 2, Section 4, D. Also GS 38 and GS 45 to DIN 1681 and GS 16 Mn5 and GS 20 Mn5 to DIN 17182</td>
</tr>
<tr>
<td>Nodular cast iron</td>
<td>≤ 300°C ≤ 40 bar ≤ DN 175 for valves and fittings</td>
<td>Nodular cast iron to Chapter 2, Section 5, B.</td>
</tr>
<tr>
<td>Lamellar (grey) cast iron: a) Boiler parts (only for unheated surfaces and not for heaters in thermal oil systems) b) Valves and fittings (except valves subject to dynamic stress) c) Exhaust gas economiser</td>
<td>≤ 200°C ≤ 10 bar ≤ 200 mm diameter ≤ 200°C ≤ 10 bar ≤ DN 175 ≤ 52 bar smoke gas temperature ≤ 600°C water outlet temperature ≤ 245°C ≤ 100 bar smoke gas temperature ≤ 700°C water outlet temperature ≤ 260°C</td>
<td>Grey cast iron to Chapter 2, Section 5, C. Grey cast iron of at least GG-25 grade to Chapter 2, Section 5, C.</td>
</tr>
<tr>
<td>Valves and fittings of cast copper alloys</td>
<td>≤ 225°C ≤ 25 bar</td>
<td>Cast copper alloys to Chapter 3, Section 2, B.</td>
</tr>
</tbody>
</table>
4.1.2 Valves fitted on unit’s side below the load waterline shall be hydrostatically tested at pressure equal to 5 bar.

4.1.3 For valves with nominal diameter greater than 25 mm in Class I and II piping systems and for valves fitted on unit’s side below the load waterline the hydrostatic test shall be carried out in the presence of a GL Surveyor or according to a special agreement.

4.1.4 For valves other than those mentioned in 4.1.3 the manufacturer’s Certificate for hydrostatic testing will be accepted.

4.2 Valve leakage tests

For all valves a leakage test shall be carried out.

The leakage test shall be performed in accordance with the design code applicable for the valve design. The leakage rate measurements shall be in accordance with the service conditions as well as code and other maritime or technical regulation requirements.

4.3 Valve operation and functional test

All valves shall be subjected to an operational / functional test at the manufacturer’s workshop. For operational / functional tests the valve shall be fully assembled with all mountings and accessories.

5. Valve sizing

All valves to be installed on offshore units/installations shall be sized according to an international recognized standard, e.g. IEC 534.

5.1 Valve sizing shall be done according to applicable and most severe service conditions.

5.2 Valves for fluid control service shall be sized and equipped with a valve trim avoiding cavitation and/or noise, so far as necessary.

5.3 The maximum allowed noise level shall be agreed on technical installation, operating and environmental requirements.

5.4 Valves for cold service (LNG) or steam service shall be equipped with an extension bonnet, as far as applicable.

5.5 Valve actuators shall be sized acc. to the maximum shut-off forces which may occur in valve service.

6. Valve marking

Each fabricated valve shall be marked with a valve name plate showing the following minimum information: Design pressure and design temperature, nominal diameter, material and valve serial number. Information about conformity and additional registration number, e.g. CE, API or ASME, shall be provided accordingly where applicable. The name plate shall be visible mounted on the valve body.

C. Process Control and Shut-off Valves for Steam Service

In addition to the general requirements defined in A. and B., process control and shut-off valves for steam service conditions shall meet the following requirements.

1. Materials

1.1 Valves and fittings for boilers and steam services shall be made of ductile materials as specified in Table 13c.1 and all their components shall be able to withstand the loads imposed in operation, in particular thermal loads and possible stresses due to vibration. Grey cast iron may be used within the limits specified in Table 13c.1, but may not be employed for valves and fittings which are subjected to dynamic loads, e.g. safety valves and blow off valves.

1.2 Testing of materials for valves and fittings shall be carried out as specified in Table 13c.2.

2. Design

Care shall be taken to ensure that the bodies of shut-off gate valves cannot be subjected to unduly high pressure due to heating of the enclosed water. Valves with screw-on bonnets shall be safeguarded to prevent unintentional loosening of the bonnet.

Table 13c.2 Testing of materials for valves

<table>
<thead>
<tr>
<th>Type of material</th>
<th>Service temperature [°C]</th>
<th>Testing required for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel, cast steel</td>
<td>&gt; 300</td>
<td>PB × DN &gt; 2500²</td>
</tr>
<tr>
<td>Steel, cast steel, nodular cast iron</td>
<td>≤ 300</td>
<td>or PB × DN &gt; 1500²</td>
</tr>
<tr>
<td>Copper alloys</td>
<td>≤ 225</td>
<td></td>
</tr>
</tbody>
</table>

1. No test is required for grey cast iron.
2. Testing may be dispensed with if DN is > 32 mm.

3. Pressure and tightness tests

3.1 All valves and fittings shall be subjected to a hydrostatic pressure test at 1.5 times the nominal pressure. Valves and fittings for which no nominal pressure has been specified shall be tested at twice the maximum allowable working pressure. In this case, the safety factor in respect of the 20 °C yield strength value shall not fall below 1.1.
3.2 The sealing efficiency of the closed valve shall be tested at the nominal pressure or at 1.1 times the maximum allowable working pressure, as applicable. Valves and fittings made of castings and subject to operating temperatures over 300 °C are required to undergo one of the following tightness tests:

− tightness test with air (test pressure approximately 0.1 x working pressure; maximum 2 bar)
− tightness test with saturated or superheated steam (test pressure may not exceed the maximum allowable working pressure)
− A tightness test may be dispensed with if the pressure test is performed with petroleum or other liquid displaying similar properties.

3.2 Pressure test and tightness tests of valves and fittings shall be carried out in the presence of the GL Surveyor.

D. Process Control and Shut-off Valves for LNG Service

In addition to the general requirements defined in A. and B. process control and shut-off valves for LNG service conditions shall meet the following requirements.

1. Design

1.1 The LNG valves shall be designed and constructed according to recognized international standards.

1.2 LNG valves with split body design are not permitted.

1.3 The LNG valves shall be of top entry design to enable maintenance of internal valve parts (trim) without disassembling the valve from the piping system.

1.4 LNG valves shall be of type approved fire safe design acc. to API 607/6FA or acc. to ISO 10497.

1.5 Valve closing time has to be determined in accordance with operating requirements of LNG plant systems.

1.6 LNG valves shall be designed with extension bonnets and bellow seal style as far as applicable. The LNG valve design shall insure that no LNG leakage will occur to the environment.

1.7 LNG valve design shall avoid any icing which may either affect the valve operation or the seal of the valve stem.

1.8 Emergency Shut Down (ESD) Valves shall be of fail safe design and shall be equipped with a pneumatic or hydraulic actuator.

1.9 LNG valves shall be designed without clearance volume inside the valve to avoid any pressure increase caused by vapourisation of enclosed LNG.

1.10 LNG valves shall have a maximum electrical resistance of 10 Ω (Ohm) and shall be so designed that no electrostatic charging may occur.

2. Materials

2.1 Materials for LNG valves shall meet LNG cryogenic temperatures and service conditions and shall comply with GL Rules, Part II - Materials and Welding.

2.2 Unless specified otherwise Table 13c.3 shall apply for selection of materials for LNG valves. Materials according to other standards, e.g. EN 1160, ASME, etc. providing a design temperature equal or less than -196 °C may be approved by GL additionally.

2.3 Manufacturers of materials as well as welding and welding personnel shall be approved accordingly.

3. Type approval

LNG valves shall be type approved.

The test requirements are outlined in GL Rules VI – Additional Rules and Guidelines, Part 7 - Guidelines for the Performance of Type Tests, Chapter 8 – Test Requirements for Components and Systems of Machinery Installations and Offshore Technology.

E. Quick Connect/Disconnect Couplings for Emergency Release Systems in LNG Service

1. General

Quick Connect/Disconnect Couplings (QC/DC) are part of the Emergency Release System (ERS) within Marine Loading Arms in LNG Service. QC/DCs are to be installed in Marine Loading Arms either for connection of LNG offshore terminals and ships, ships to shore or between ship and ship. The purpose of QC/DC is to connect/disconnect manifold flanges of flexible hoses which are connected with marine loading arms.

The QC/DC within the ERS shall consist of a double acting valve combined with an emergency release coupling. The combination with integrated shut-off valves is acceptable. The design shall be based on recognized international technical standards and shall be type approved by GL prior to fabrication and installation. QC/DCs are normally hydraulically operated when used on marine loading arms with ERS. If a hydraulic power supply is not available, a QC/DC shall be operated manually.
Table 13c.3 Materials for pipes (seamless and welded), forgings and castings for cargo and process piping for design temperatures below 0° C and down to -165° C 1,2,3 Maximum thickness 25 mm

<table>
<thead>
<tr>
<th>Minimum design temperature [°C]</th>
<th>Chemical composition 5 and heat treatment</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Test temperature [°C]</td>
</tr>
<tr>
<td>-55    Carbon-Manganese steel. Fully killed fine grain. Normalized or as agreed 6</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>-65    2.25 % Nickel steel. Normalized or normalized and tempered 6</td>
<td></td>
<td>-70</td>
</tr>
<tr>
<td>-90    3.5 % Nickel steel. Normalized or normalized and tempered 6</td>
<td></td>
<td>-95</td>
</tr>
<tr>
<td>-165   9 % Nickel steel 7. Double normalized and tempered or quenched and tempered</td>
<td></td>
<td>-196</td>
</tr>
<tr>
<td>Austenitic steels (e.g. types 304, 304L, 316, 316L, 321 and 347) Solution treated 8</td>
<td></td>
<td>-196</td>
</tr>
<tr>
<td>Aluminium alloys; e.g. type 5083 annealed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tensile and toughness (impact) test requirements

| Impact test | Each batch to be tested. Longitudinal test pieces. |

Notes:
1. The use of longitudinally or spirally welded pipes is to be specially approved by GL.
2. The requirements for forgings and castings may be subject to special consideration.
3. The requirements for design temperatures below -165° C are to be specially agreed.
4. The test temperature is to be 5° C below the design temperature or -20° C whichever is lower.
5. The composition limits are to be approved by GL.
6. A lower design temperature may be specially agreed for quenched and tempered materials.
7. This chemical composition is not suitable for castings.
8. Impact tests may be omitted subject to agreement with GL.

2. Design

2.1 The design of the QC/DC coupling as a part of the ERS shall consider all applicable risk and safety requirements. According to current IMO regulations QC/DC couplings are specific safety valves as these items are part of the ERS. Accordingly, the design of a QC/DC shall include a Failure Mode and Effects Analysis (FMEA) which shall analyse the design on possible failures such as the following:
   - structural analysis of the QC/DC
   - operational analysis
   - failure analysis and risk assessment

2.2 The QC/DC shall ensure a satisfactory disconnection between the marine loading arm and the flexible hose, either for ship to shore service or for ship to ship / offshore platform service.

2.3 The correct assembly of the QC/DC after disconnection shall be ensured through optical / visual and mechanical alignments.

2.4 The valves of QC/DCs shall be closed in case of opening of coupling and/or loss of electric or hydraulic power supply or manual operation (normally closed).

2.5 Maximum shut-off time of integrated shut-off valves from OPEN to CLOSED position is limited to 30 seconds.

2.6 The QC/DC shall operate reliably under icing caused by LNG flow. The QC/DC shall disconnect satisfactorily under any possible icing. Shut-off valves shall be closed (tight shut-off) prior to disconnection.

2.7 No leakage of the QC/DC shall occur under any service and operating conditions.

2.8 No leakage shall occur after closing of the shut-off valves and opening of the QC/DC coupling.

2.9 No leakage of any closed valves shall occur when the QC/DC coupling is disconnected.
2.10 To avoid any leakage and/or uncontrolled outlet flow of LNG/other liquids, the opening of the QC/DC coupling shall be possible only, if the additional shut-off valves are closed.

2.11 For QC/DCs without integral shut-off valve a locking device shall be integrated to prevent opening during fluid (LNG) transfer.

2.12 A fire safe design according to ISO 10497 or API 607/6FA shall be provided.

2.13 No risk of spark formation is allowed on actuation of the QC/DC

2.14 The correct operation of the QC/DC shall not be affected through any movement of the LNG flexible hose and the additional marine loading arm, e.g. caused by vibrations and/or shear tensions. Further the QC/DC shall be designed to prevent any inadvertent release caused by any movement or vibrations of the flexible hose and/or the marine loading arm.

2.15 The two shut off valves shall be operated separately from the coupling when the QC/DC is closed.

2.16 The QC/DC coupling shall perform with long lifetime operational reliability under influence of saline atmosphere.

2.17 Documentation

Documents to be submitted for approval upon request by GL:
- Data sheet showing service and operating conditions including valve type and size.
- Assembly drawing of valve and actuator including all mounted accessories and detailed parts list.
- Drawings of pressurized parts and which are in contact with flowing media including complete parts list showing materials used for design.
- Design calculations, sizing calculations for flow service and actuator layout
- FMEA Analysis of QC/DC
- Material Certificates, if available
- Leakage Test Certificate, if available
- Pressure Test Certificate, if available
- Cold Shock Test Certificate, if available
- Test Certificate about combined strength test and leakage measurement, if available
- Test Certificate about QC/DC operation and disconnect test including leakage measurement under icing, if available
- Salt mist test, if available
- Fire Safety Test Certificate, if available

3. Materials

Materials of QC/DC couplings for LNG service shall comply with the material requirements for LNG valves listed under D.2.

Materials of QC/DC couplings for sour gas service shall be corrosion resistant and shall comply with the NACE MR 01-75 standard, see also Section 15.

4. Type approval

The QC/DC couplings shall be of type approved design.

The detailed test requirements are outlined in GL Rules VI – Additional Rules and Guidelines, Part 7 - Guidelines for the Performance of Type Tests, Chapter 8 – Test Requirements for Components and Systems of Machinery Installations and Offshore Technology.

F. Safety Valves and Safety Devices for Protection against Overpressure

1. General

1.1 Scope

The following requirements apply accordingly to safety valves and safety devices for protection against overpressure in pressurised systems, such as e.g. pressure vessels, steam boilers or heat exchangers.

For all safety valve types defined below the general expression “safety valve” will be used in the following.

1.2 Definitions

1.2.1 Safety valve

A safety valve is a valve which automatically, without the assistance of any energy other than that of the fluid concerned, discharges a quantity of the fluid so as to prevent a predetermined safe pressure from being exceeded.

It is designed to re-close and prevent further flow of fluid after normal pressure conditions of service have been restored.

1.2.2 Directly loaded safety valve

This is a safety valve in which the loading due to the fluid pressure underneath the valve disc is opposed only by a direct mechanical loading device such as a weight, lever and weight, or a spring.

1.2.3 Safety shut-off valve

A safety shut-off valve is a valve which closes automatically to prevent a predetermined gauge pressure being exceeded.
1.2.4 Pilot operated safety valve
The operation of a pilot operated safety valve is initiated and controlled by the fluid discharged from a pilot valve which is itself a directly loaded safety valve subject to the requirement of this standard.

1.2.5 Bellows safety valve
A bellows safety valve is a directly loaded safety valve wherein sliding and rotating elements (partially or fully) and springs are protected against the effects of the fluid by bellows. The bellows may be of such a design that it compensates for influences of back pressures.

1.2.6 Balanced bellows
Balanced bellows are devices which minimise the effect of superimposed back pressure on the set pressure of a safety valve.

1.2.7 Controlled safety valve
A controlled safety valve consists of a main valve and a control device. It also includes direct acting safety valves with supplementary loading in which, until the set pressure is reached, an additional force increases the closing force.

1.2.8 Set pressure
The set pressure is the predetermined gauge pressure at which under operating conditions:
- a directly loaded safety valve commences to lift, or
- a controlled safety valve commences to initiate the opening of the main valve.

1.2.9 Overpressure
Overpressure is the pressure above the set pressure, at which the safety valve attains the lift specified by the manufacturer, usually expressed as a percentage of the set pressure.

1.2.10 Functional test pressure
The functional test pressure is the gauge pressure at which under test stand conditions (atmospheric back pressure):
- a directly loaded safety valve commences to lift, or
- a controlled safety valve commences to initiate the opening of the main valve.

1.2.11 Flow area
The flow area is defined as the minimum cross-sectional area (but not the curtain area) between inlet and seat and is used to calculate the theoretical flow capacity, with no deduction for any obstruction.

1.2.12 Flow diameter
This is the diameter corresponding to the flow area.

1.2.13 Discharge capacities

1.2.13.1 Actual discharge capacity
The actual discharge capacity is the flow capacity determined by measurement.

1.2.13.2 Theoretical discharge capacity
The theoretical discharge capacity is the calculated capacity expressed in mass or volumetric units of a theoretically perfect nozzle having a cross-sectional flow area equal to the flow area of a safety valve.

1.2.13.3 Certified discharge capacity
The certified discharge capacity is that portion of the measured capacity permitted to be used as a basis for the application of a safety valve.

1.2.13.4 Coefficient of discharge
The coefficient of discharge is the value of the actual discharge capacity divided by the theoretical discharge capacity.

2. Design

2.1 General requirements

2.1.1 Safety valves shall be state-of-the-art design according to an international recognized technical standard and shall ensure a safe operation and seat tightness. The pressure / temperature ratings shall be specified in accordance with the applicable design code. The design shall consider the type of flowing media which may be liquid, gas or two phase flow.

2.1.2 The design stress of all pressure and load carrying parts shall not exceed the allowable stress specified in the applicable safety valve design standard.

2.1.3 The seat of a safety valve, if it is not an integral part of the valve shell, shall be fastened securely to prevent the seat becoming loose in service.

2.1.4 Means shall be provided to lock and/or to seal all external adjustments in a manner to prevent or reveal unauthorised adjustments of the safety valve.

2.1.5 Safety valves for toxic or flammable fluids shall be of the closed bonnet type to avoid any kind of leakage to the atmosphere or if vented, the fluid shall be disposed off to a safe place.

2.1.6 Provision shall be made to prevent liquid collecting on the discharge side of the safety valve shell.

2.1.7 Safety valves shall be designed and constructed in a way that breakage of any part, or failure of any device, will not obstruct free and full discharge through the valve.
2.1.8 Safety valves shall be designed so that the maximum required capacity can be discharged without the maximum allowable working pressure being exceeded by more than 10%.

2.1.9 The materials for adjacent sliding surfaces such as guide(s) and disc/disc holder/spindle shall be selected to ensure corrosion resistance and to minimise wear.

2.1.10 Sealing elements, which may adversely affect the operating characteristics by frictional forces, are not permitted.

2.1.11 Safety valves are to be designed so that no binding or jamming of moving parts is possible even under hot and cold temperature conditions. Seals which may prevent the operation of the safety valve due to frictional forces are not permitted.

2.1.12 Controlled safety valves are permitted wherever they are reliably operated without any external energy source. Operation with external energy shall be approved by GL.

2.1.13 Safety valves for steam service shall additionally meet the design requirements listed under G.

2.1.14 Design of safety valve end connections
The design of safety valve end connections shall be in accordance with international recognised technical design codes.

2.2 Safety valve documents for approval
For each type and size of a safety valve the following documents shall be provided to GL for approval:

a) Safety valve drawing
   Drawing showing complete assembled safety valve with all parts numbered. The valve serial number is to be placed on the drawing if available.

b) Safety valve parts list
   Parts lists showing all numbered parts and items in accordance with additional safety valve drawing including material and related material code specification.

c) Design calculations
   Design calculation acc. to related design code.

d) Safety valve data sheet
   The safety valve data sheet shall include description and type of safety valve, detailed design requirements, service and operation conditions, type of fluid to be discharged, discharge capacity, etc.

e) Material Certificates, if available
   Material Certificates must be related to each safety valve and type, e.g. using the safety valve serial number, to ensure correct material selection acc. to safety valve design requirements.

f) Non destructive examination records / NDE records, if available

g) Pressure test Certificates, if available

h) Safety valve performance test records, if available.

i) Type approval Certificate, so far not issued by GL.

2.3 Scope of documentation for each specific safety valve type and size
All parts of the safety valve documentation described above shall be issued completely for each valve type and size. All documents, such as e.g. drawings, data sheets, material and test Certificates, shall be related to each other for each specific valve type and size by a specific numbering or document relationship system, e.g. valve serial numbering.

3. Materials
The selection of materials for all safety valve parts - safety valve body and internal parts (trim) as well as additional equipment - shall be based on the service and operating conditions in conjunction with pressure and temperature ratings, corrosive and erosive properties of the flowing media.

Materials for safety valves shall comply with GL Rules, Part II - Materials and Welding. Other materials to be used for safety valve design and construction which are not included in GL Rules shall be approved by Germanischer Lloyd.

Valve materials for sour gas service shall comply with NACE MR 01-75, see also Section 15.

4. Type approval
The safety valves shall be of type approved design in accordance with recognized international standards.

The detailed test requirements are outlined in GL Rules VI – Additional Rules and Guidelines, Part 7 - Guidelines for the Performance of Type Tests, Chapter 8 – Test Requirements for Components and Systems of Machinery Installations and Offshore Technology.

5. Design changes
If the type tested and/or type approved safety valve or any single safety valve items or parts will be modified in its design in such a manner as to affect the flow area, lift or performance characteristics, the existing type approval will lose its validity. The design modification will require new tests which shall be carried out in accordance with the requirements of the applicable safety valve design code and the previously listed items.

6. Marking of safety valves

6.1 Marking and sealing of safety valves
Marking on the body of a safety valve may be integral with the body or on a plate securely fixed on the safety
valve body. The following minimum information shall be marked on all safety valves:

a) Nominal size (inlet size), for example DN xxx;
b) Material designation of the shell;
c) Manufacturer's name or trade-mark;
d) An arrow showing the direction of flow where the inlet and outlet connections have the same dimensions or the same pressure rating.

6.2 Marking on safety valve type plate / identification plate

The following information shall be given on an identification plate securely fixed to the safety valve:

a) Set pressure, in bar gauge;
b) The applicable design standard;
c) Manufacturer's type reference;
d) Certified coefficient of discharge indicating reference fluid:
   ‘G’ for gas, ‘S’ for steam and ‘L’ for liquid;
e) Flow area, in square millimetres;
f) Minimum value of the lift, in millimetres, and corresponding overpressure, expressed as, e.g. a percentage of set pressure.

6.3 Sealing of safety valves

All adjustments shall be sealed to avoid any unauthorized alteration

7. Installation of safety valves

Unless specified otherwise by GL Construction Rules the following requirements will apply for installation of safety valves:

7.1 No forces and/or loads caused by static and dynamic stresses or thermal expansion of connected piping systems may be transmitted to the installed safety valve.

7.2 No undue vibrations shall be transmitted to the installed safety valve.

7.3 Safety valves shall be installed free accessible for inspection and maintenance.

7.4 The connections between the safety valve and the pressurized system shall be designed and constructed sufficiently considering also the applicable technical design code to avoid any failure of the connection.

G. Safety Valves for Steam and Steam Boiler Service

1. In addition to the requirements defined in F. safety valves for steam and steam boiler service conditions shall meet the requirements listed in Section 12a.

2. The set pressure test shall be carried out in presence of a GL Surveyor.

H. Safety Valves for LNG Service

In addition to the requirements defined in F. safety valves for LNG service shall meet the following requirements.

1. Design

Safety valves for LNG service shall be designed according to recognized international standards.

For LNG safety valves in ship service design and sizing has to be carried out according to GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 6 - Liquefied Gas Tankers.

2. Materials

Materials for LNG safety valves shall meet LNG cryogenic temperatures and service conditions and shall comply with GL Rules II - Materials and Welding. Further requirements see D.2.

3. Testing

Pressure relief valves are to be prototype tested to ensure that the valves have the capacity required. According to the type approval requirements defined in F.5. each valve is to be tested to ensure that it opens at the prescribed pressure setting without exceeding the following tolerances:

\[ \pm 10 \% \] for pressure from 0 to 1.5 bar
\[ \pm 6 \% \] for pressure from 1.5 to 3.0 bar
\[ \pm 3 \% \] from pressure above 3.0 bar

Pressure relief valves are to be set and sealed under monitoring of GL and a record of this action, including the values of set pressure, is to be retained aboard the LNG facility.

Type approval testing includes safety valve testing at design temperature.
I. Remote Control of Valves

1. Scope

These requirements apply to hydraulically, pneumatically or electrically operated valves in piping systems and sanitary discharge pipes.

2. Construction

Remote controlled bilge valves and valves important for the safety of the unit are to be equipped with an emergency operating arrangement.

3. Arrangement of valves

3.1 Accessibility

The accessibility of the valves for maintenance and repair is to be taken into consideration. Valves in bilge lines and sanitary pipes shall always be accessible.

3.2 Bilge lines

Valves and control lines are to be located as far as possible from the bottom and sides of the unit.

3.3 Ballast lines

The requirements stated in 3.2 also apply here to the location of valves and control lines.

Where remote controlled valves are arranged inside the ballast tanks, the valves should always be located in the tank adjoining that to which they relate.

3.4 Fuel lines

Remote controlled valves mounted on fuel tanks located above the double bottom shall be capable of being closed from outside the compartment in which they are installed. (see also Section 13e, D.2.).

If remote controlled valves are installed inside fuel or oil tanks, 3.3 has to be applied accordingly.

3.5 Bunker lines

Remote controlled shut-off devices mounted on fuel tanks shall not be automatically closed in case the power supply fails, unless suitable arrangements are provided, which prevent inadmissible pressure raise in the bunker line during bunkering.

4. Control stands

4.1 The control devices of remote controlled valves of a system are to be arranged together in one control stand.

4.2 The control devices are to be clearly and permanently identified and marked.

4.3 The status (open or close) of each remote controlled valve is to be indicated at the control stand.

4.4 The status of bilge valves "open"/"close" is to be indicated by GL approved position indicators.

In case of position indicators directly mounted on the valve a drawing approval by GL is to be carried out.

Position indicators based on indirect measuring principles, i.e. volumetric position indicators, need to be approved.

4.5 In case of volumetric position indicators the system pressure of the control line is to be monitored by a GL type approved pressure switch (series connection of pressure switch and flow switch).

4.6 The control devices of valves for changeable tanks are to be interlocked to ensure that only the valve relating to the tank concerned can be operated.

5. Power units

5.1 Power units are to be equipped with at least two independent sets for supplying power for remote controlled valves.

5.2 The energy required for the closing of valves which are not closed by spring power is to be supplied by a pressure accumulator.

5.3 Pneumatically operated valves may be supplied with air from the general compressed air system.

Where quick-closing valves of fuel tanks are closed pneumatically, a separate pressure accumulator is to be provided. This is to be of adequate capacity and is to be located outside the engine room. Filling of this accumulator by a direct connection from the general compressed air system is allowed. A non-return valve is to be arranged in the filling connection of the pressure accumulator.

The accumulator is to be provided either with a pressure control device with a visual and audible alarm or with a hand-compressor as a second filling appliance.

The hand-compressor is to be located outside the engine room.

6. After installation on board, the entire system is to be subjected to an operational test.
Section 13d

General Design of Piping Systems

A. General

1. Scope

The following requirements apply to piping systems, fittings, flexible hoses and all steel flexible lines on fixed drilling, production and processing offshore installations as well as on mobile offshore units.

The requirements of this Section are not applicable to pipelines laid on or in the seabed. These pipelines are subject to the GL Rules IV – Industrial Services, Part 8 – Pipelines.

The selection and dimensioning of well casings and tubing is not covered by this Section. This scope belongs to the responsibility of the drilling contractor and is covered by other relevant specifications or recognized international standards.

2. Reference

2.1 This Section defines the basic requirements for the application of different piping systems. Further requirements for piping and auxiliary systems for specific services are outlined in the Sections 13e and 13f, as well as in Section 13a.

2.2 The design of control valves, shut-down valves, safety valves or other types of valves installed in the piping system as well as the requirements for their testing are defined in Section 13c.

B. Design Principles

1. General design conditions

Each piping system for offshore installations and units will have to be designed according to the service and operating conditions as well as the environmental conditions required and specified for the actual case. The design has to take into consideration the most severe process service and operating conditions.

The piping design will have to be carried out under consideration of international and recognized standards applicable for the specific type of service conditions.

The piping system for the shipboard operation of self-propelled units or non-self-propelled, towed barges are to be designed according to the GL Rules I – Ship Technology, Part 1 - Seagoing Ships, Chapter 2 – Machinery Installations.

2. Definitions

2.1 Loads

2.1.1 Design loads

Depending on the different service conditions the following design loads have to be distinguished and may be adequately combined:

2.1.2 Dead loads

Dead loads are loads such as weight, insulation and other permanent loads supported by the piping.

2.1.3 Live loads

Live loads are caused by the design pressure, density and velocity of the flowing media.

2.1.4 Thermal loads

Thermal loads are caused by thermal expansion or temperature gradients and occur if the free movement of the piping system is prevented or restricted by its mounting.

2.1.5 Environmental loads

2.1.5.1 Wind loads

Wind loads on piping systems at the open deck shall be determined by using statistical data for the location of the installation/unit or conservative estimates, compare Chapter 4 – Structural Design, Sections 1 and 2.

2.1.5.2 Loads due to ice and snow

For pipelines in the open and for relevant service locations of the installation/unit the design analysis shall include loads due to ice and snow on the surface of the pipes and the foundations.

2.1.6 Other operational loads

Operational loads other than specified above, to which the piping system may be subjected during its design life, e.g. vibrations or shock waves, shall be considered in the design analysis.

2.2 Pressures

2.2.1 Maximum allowable working pressure, PB [bar]; Formula symbol: $p_{e,zul}$

This is the maximum allowable internal or external working pressure for a component or piping system with regard to the materials used, piping design re-
quirements, the working temperature and undisturbed operation.

2.2.2 Nominal pressure, PN [bar]
This is the term applied to a selected pressure temperature relation used for the standardization of structural components. In general, the numerical value of the nominal pressure for a standardized component made of the material specified in the standard will correspond to the maximum allowable working pressure $P_B$ at 20 °C.

2.2.3 Test pressure, PP [bar]; formula symbol: $P_p$
This is the pressure to which components or piping systems are subjected for testing purposes.

2.2.4 Design pressure, PR [bar]; formula symbol: $P_c$
This is the maximum allowable working pressure $P_B$ for which a component or piping system is designed with regard to its mechanical characteristics. In general, the design pressure is the maximum allowable working pressure at which the safety equipment will interfere (e.g. activation of safety valves, opening of return lines of pumps, operating of overpressure safety arrangements, opening of relief valves) or at which the pumps will operate against closed valves.

2.3 Design media
Design medium is the flowing medium (liquid, gas or two phases) suitable for the design of the piping system including material selection.

3. Design temperature

3.1 The design temperature "$t" is normally understood as the maximum temperature ($t_{\text{max}}$) of the internal fluid, but not less than + 50 °C. If low temperature conditions are expected during winter operation, by gas expansion chilling or other reasons, a minimum design temperature limit "$t_{\text{min}}" has to be defined in addition to "$t".

3.2 In case of steam pipes, discharge pipes from air compressors and starting air piping to internal combustion engines, the design temperature is to be at least 200 °C.

3.3 Design temperatures for superheated steam lines are as follows:
a) Pipes behind desuperheaters:
   - with automatic temperature control: the working temperature (design temperature)
   - with manual control: the working temperature + 15 °C
b) Pipes before desuperheaters:
   - the working temperature + 15 °C

4. Documents for approval

4.1 Piping and instrumentation diagrams (P & ID)
Piping and Instrumentation Diagrams (P & ID) shall be submitted to GL in triplicate and shall contain all relevant data for material selection, operation and safety.

Information to be included in P& IDs for pipe identification:
- pipe / line number
- design and operating pressure
- design and operating temperature
- material specification
- diameters / nominal diameters and wall thickness
- information about valves, measurement and control units / applications
- information about pipe classes
- locations of drainage and breather units

4.2 Process flow diagrams and heat balance diagram
- information emphasizing specific risks resulting from flow characteristics, i.e. multiple phase flow, slugs, specific gravity, mud or formation particles
- characteristics of liquids or gases carried, i.e. corrosive, toxic, sour gas, non-corrosive, mass fractions of deposits, such as paraffin or hydrates as well as chemicals, inhibitors or tensides/surfactants

4.3 For steam lines with working temperatures above 400°C the corresponding stress calculation together with isometric data shall be submitted.

4.4 For wall thickness design and pipe stress calculations, see also D.

4.5 Details of hoses and expansion joints made of non-metallic materials shall be clearly marked.

4.6 Welded piping systems
For welded piping systems the following documentation has to be provided additionally:
- Welding Procedure Specifications (WPS)
- Procedure Qualification Record (PQR)
- For further details see GL Rules II – Materials and Welding, Part 3 – Welding.

5. Classes of piping systems
For the purpose of verification of dimensioning, material selection, welding procedures, heat treatment, joint selection and testing requirements, pipes are divided into three pipe classes as indicated in Table 13d.1.
Table 13d.1 Classification of pipes into pipe classes

<table>
<thead>
<tr>
<th>Medium/type of pipes into pipe classes</th>
<th>Design pressure PR [bar]</th>
<th>Design temperature t [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe class</td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Toxic media</td>
<td>all</td>
<td>all</td>
</tr>
<tr>
<td>Corrosive media</td>
<td>all</td>
<td>1</td>
</tr>
<tr>
<td>Inflammable media with service temperature above flash point</td>
<td>PR &gt; 16 or t &gt; 300</td>
<td>PR ≤ 16 or t ≤ 300</td>
</tr>
<tr>
<td>Inflammable media with a flash point of 60° C or less</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquefied gases (LG)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td>PR &gt; 16 or t &gt; 300</td>
<td>PR ≤ 16 or t ≤ 300</td>
</tr>
<tr>
<td>Thermal oil</td>
<td>PR &gt; 16 or t &gt; 300</td>
<td>PR ≤ 16 or t ≤ 300</td>
</tr>
<tr>
<td>Air, gas</td>
<td>PR &gt; 40 or t &gt; 300</td>
<td>PR ≤ 40 or t ≤ 300</td>
</tr>
<tr>
<td>Non-flammable hydraulic fluid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boiler feedwater, condensate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seawater and fresh water for cooling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brine in refrigerating plant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid fuels, lubricating oil, flammable hydraulic fluid</td>
<td>PR &gt; 16 or t &gt; 150</td>
<td>PR ≤ 16 or t ≤ 150</td>
</tr>
<tr>
<td>Cargo pipelines for oil tankers</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Cargo and venting lines for gas and chemical tankers</td>
<td>all</td>
<td>–</td>
</tr>
<tr>
<td>Refrigerants</td>
<td>–</td>
<td>all</td>
</tr>
<tr>
<td>Open-ended pipelines (without shutoff), e.g. drains, venting pipes, overflow lines and boiler blowdown lines</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

1 Classification in Pipe Class II is possible if special safety arrangement are available and structural safety precautions are arranged.

C. Materials and Testing

1. General

Materials to be used for pipe systems to be installed in offshore installations/units including valves and fittings shall be suitable for the different services and shall comply with the GL Rules II – Materials and Welding.

In case of especially corrosive media, GL may impose special requirements on the material used. For welds, see GL Rules II – Materials and Welding, Part 3 – Welding. For the material used for pipes and valves for steam boilers see Section 12a.

2. Materials

2.1 Material manufacturers

Pipes, elbows, fittings, valve casings, flanges and semi-finished products intended to be used in pipe class I and II are to be manufactured by GL approved manufacturers.

For the use in pipe class III piping systems an approval according to other recognized standards may be accepted.

2.2 Pipes, valves and other fittings of steel

2.2.1 Pipes belonging to Classes I and II shall be seamless drawn steel pipes or pipes fabricated in accordance with a welding procedure approved by GL to be equivalent to seamless pipes. The use of welded pipes is limited in certain hydrocarbon services.

2.2.2 For corrosive hydrocarbon service corrosion resistant materials are required.

Special consideration has to be given in cases of media containing chloride (danger of chloride stress cracking) or containing sour gas (danger of hydrogen sulphide cracking). Materials for piping systems for
sour gas service have to comply with the requirements of Section 15.

2.2.3 In general, carbon and carbon-manganese steel pipes, valves and other fittings shall not be employed for temperatures above 400 °C. For applications above 400 °C approval by GL has to be asked for.

2.3 Pipes, valves and fittings of copper and copper alloys

Pipes of copper and copper alloys shall be of seamless drawn material or fabricated according to a method approved by GL. Copper pipes for Classes I and II shall be seamless.

Copper and copper alloys shall not, for reasons of anticipated corrosive reactions, be used in hydrocarbon services. The use is to be limited to auxiliary and utility services if the following requirements are observed.

In general, copper and copper alloy pipe lines shall not be used for media having temperatures above the following limits:

- copper and aluminium brass 200 °C
- copper nickel alloys 300 °C
- high-temperature bronze 260 °C

2.4 Pipes, valves and fittings of nodular ferritic cast iron

2.4.1 Nodular cast iron shall not be used in hydrocarbon services. It may be accepted in auxiliary or utility systems with the following limitations.

2.4.2 Nodular cast iron of the ferritic type according to the GL Rules II - Materials and Welding may be accepted for bilge, ballast and oil or gas piping within tanks or for other purposes approved by GL.

2.4.3 Ferritic nodular cast iron valves and other fittings may be accepted for media having temperatures not exceeding 350 °C. The use of this material for pipes, valves and fittings for other services, in principle for pipe Classes II and III, will be subject to special approval by GL.

On offshore units nodular cast iron pipes and valves fitted on the unit's side shall comply with the GL Rules II – Materials and Welding in accordance with the intention of Regulation 22 of the 1966 Convention on Load Lines.

2.5 Grey cast iron pipes and fittings

Pipes and fittings of grey cast iron may be accepted by GL for Class III. Pipes of grey cast iron may be used for cargo pipelines within cargo tanks of FPSO/FPO/FSO.

Pipes and fittings of grey cast iron may be used for cargo lines on the weather deck of FPSO/FPO/FSO up to a working pressure of 16 bar.

Ductile materials shall be used for cargo hose connections and distributor headers.

This applies also to the hose connections of fuel and lubricating oil filling lines.

The use of grey cast iron is not allowed:
- for pipes and fittings for media having temperatures above 220 °C and for pipelines subject to water hammer, severe stresses or vibrations
- for pipes fitted on the unit sides and for valves fitted on the collision bulkhead
- for valves on fuel and oil tanks subject to static head

The use of grey cast iron for other services will be subject to GL approval.

2.6 Plastic pipe systems

2.6.1 Plastic piping systems are to be approved by GL. 1

Each applicable pipe connection, i.e. flange-, adhesive bond joint or bell and spigot connections, is to be included in the approval programme. Regarding the use of flex type pipe couplings, E.2.6 is to be observed.

2.6.2 Plastic piping systems including valves are to be designed and manufactured according to recognized standards.

2.6.3 Pipe penetrations through watertight bulkheads and decks as well as through fire divisions are to be approved by GL.

2.6.4 The use of plastic piping systems is approved for piping systems included in pipe class III only.

Dependent on the application and installation location specific means respectively additional flame tests may be required. 1

2.7 Aluminium and aluminium alloys

2.7.1 Aluminium and aluminium alloys shall comply with the GL Rules II - Materials and Welding and may in individual cases, with the agreement of GL, be used for temperatures up to 200 °C. They are not acceptable for use in fire extinguishing lines.

2.7.2 Aluminium and aluminium alloys shall not be used in hydrocarbon piping systems.

2.8 Application of materials

For the pipe classes defined in B.5, materials are to be selected according to Table 13d.2.

1 See IMO Resolution A.753 (18), “Guidelines for the Application of Plastic Pipes on Ships".
<table>
<thead>
<tr>
<th>Material or application</th>
<th>Pipe class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td><strong>Pipes</strong></td>
<td>Steel pipes for high temperatures above 300 °C, pipes made of steel with high/low-temperature toughness at temperatures below -10 °C, stainless steel pipes for chemicals</td>
</tr>
<tr>
<td>Forgings, plates, flange, steel sections and bars</td>
<td>Steel suitable for the corresponding service and processing conditions, high temperature steel for temperatures above 300 °C, steel with high/low-temperature toughness for temperatures below -10 °C</td>
</tr>
<tr>
<td>Bolts, nuts</td>
<td>Bolts for general machinery constructions, high-temperatures above 300 °C, steel with high/low-temperature toughness at temperatures below -10 °C</td>
</tr>
<tr>
<td><strong>Cast steel</strong></td>
<td>High-temperature cast steel for temperatures above 300 °C, cast steel with high/low-temperatures toughness at temperatures below -10 °C, stainless castings for aggressive media</td>
</tr>
<tr>
<td>Nodular cast iron</td>
<td>Only ferritic grades, elongation A₅ at least 15 %</td>
</tr>
<tr>
<td>Cast iron with lamellar graphite</td>
<td>–</td>
</tr>
<tr>
<td>Copper, copper alloys</td>
<td>In cargo lines on chemical tankers only with special approval, low-temperature copper-nickel-alloys by special agreement</td>
</tr>
<tr>
<td>Aluminium, aluminium alloys</td>
<td>In cargo and processing lines on gas tankers</td>
</tr>
<tr>
<td><strong>Plastics</strong></td>
<td>–</td>
</tr>
</tbody>
</table>
Table 13d.3 Approved materials and types of material Certificates

<table>
<thead>
<tr>
<th>Type of component</th>
<th>Approved materials</th>
<th>Design temperature</th>
<th>Pipe class</th>
<th>Nominal diameter DN</th>
<th>Type of Certificate ²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Pipes¹, Pipe elbows, Fittings</td>
<td>Steel, Copper, Copper alloys, Aluminium, Aluminium alloys, Plastics</td>
<td>–</td>
<td>I + II</td>
<td>&gt; 50</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤ 50</td>
<td>–</td>
<td>×</td>
</tr>
<tr>
<td>Valves¹, Flanges,</td>
<td>Steel, Cast steel, Nodular cast iron</td>
<td>&gt; 300 °C</td>
<td>I, II</td>
<td>DN &gt; 100</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Copper, Copper alloys</td>
<td>&gt; 225 °C</td>
<td>I, II</td>
<td>DN ≤ 100</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Steel, Cast steel, Nodular cast iron</td>
<td>≤ 300 °C</td>
<td>I, II</td>
<td>PB × DN &gt; 2500 or DN &gt; 250</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PB × DN ≤ 2500 or DN ≤ 250</td>
<td>–</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Steel, Cast steel, Nodular cast iron, Grey cast iron</td>
<td>–</td>
<td>III</td>
<td>All</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Copper, Copper alloys</td>
<td>≤ 225 °C</td>
<td>I, II</td>
<td>PB × DN &gt; 1500</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Aluminium, Aluminium alloys</td>
<td>≤ 200 °C</td>
<td>I, II</td>
<td>PB × DN ≤ 1500</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Plastics</td>
<td>Acc. to Type Approval Certificate</td>
<td>III</td>
<td>All</td>
<td>–</td>
</tr>
<tr>
<td>Semi-finished products, Screws and other components</td>
<td>According to Table 11.2</td>
<td>–</td>
<td>I, II</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

¹ Casings of valves and pipes fitted on ship's side and bottom and bodies of valves fitted on collision bulkhead are to be included in pipe class II

² Test Certificates are to be issued in accordance with GL Rules II – Materials and Welding, Part 1 – Metallic Materials, Chapter 1 – Principles and Test Procedures, Section 1, H.

A: GL Material Certificate,  B: Manufacturer Inspection Certificate,  C: Manufacturer Test Report
3. Testing of materials

3.1 For piping systems belonging to class I and II, tests in accordance with GL Rules II – Materials and Welding, Part 1 – Metallic Materials and under GL supervision are to be carried out in accordance with Table 13d.3 for:
- pipes, bends and fittings
- valve bodies and flanges
- valve bodies and flanges > DN 100 in cargo and process lines on gas tankers with design temperature < –55 °C

3.2 Welded joints in lines of classes I and II are to be tested in accordance with II – Materials and Welding, Part 3 – Welding.

4. Hydraulic tests of pipes

4.1 Pressure test prior to installation on board

4.1.1 All Class I and II pipes as well as steam lines, feed water pressure pipes, compressed air and fuel lines having a design pressure PR greater than 3,5 bar together with their integral fittings, connecting pieces, branches and bends, after completion of manufacture but before insulation and coating, if this is provided, shall be subjected to a hydraulic pressure test in the presence of the Surveyor at the following value of pressure:

\[ p_p = 1,5 \cdot p_c \text{ [bar]} \]

where \( p_c \) is the design pressure. For steel pipes and their integral fittings intended to be used in systems with working temperature above 300 °C the test pressure \( P_P \) is to be as follows:

\[ p_p = 1,5 \cdot \left( \frac{\sigma_{zul}(100\degree C)}{\sigma_{zul}(t)} \cdot p_c \right) \]

\( \sigma_{zul}(100\degree) \) = permissible stress at 100 °C
\( \sigma_{zul}(t) \) = permissible stress at the design temperature \( t \) [°C]

However, the test pressure need not exceed:

\[ p_p = 2 \cdot p_c \text{ [bar]} \]

With the approval of GL, this pressure may be reduced to 1,5 \( p_c \) where it is necessary to avoid excessive stress in way of bends, T-pieces and other shaped components.

In no case may the membrane stress exceed 90 % of the yield strength or 0,2 % of the maximum elongation.

4.1.2 Where for technical reasons it is not possible to carry out complete hydraulic pressure tests on all sections of piping before assembly on board, proposals are to be submitted to GL for approval for testing pipe connections on board, particularly in respect of welding seams.

4.1.3 Where the hydraulic pressure test of piping is carried out on board, these tests may be conducted in conjunction with the tests required under 4.2.

4.1.4 Pressure testing of pipes with less than DN 15 may be omitted at GL’s discretion depending on the application.

4.2 Test after installation on board

4.2.1 After assembly on board, all pipelines covered by these requirements are to be subjected to a tightness test in the presence of a GL Surveyor. In general, all pipe systems are to be tested for leakage under operational conditions. If necessary, special techniques other than hydraulic pressure tests are to be applied.

4.2.2 Heating coils in tanks and pipe lines for fuels are to be tested to not less than 1,5 PR but in no case less than 4 bar.

4.3 Pressure testing of valves

For testing of valves see Section 13c, for shut-off devices for boilers, see Section 12a, E.

5. Structural tests, heat treatment and non-destructive testing

Attention should be given to the workmanship in construction and installation of the piping systems according to the approved data in order to obtain the maximum efficiency in service. For details concerning structural tests and tests following heat treatments, see GL Rules II – Materials and Welding, Part 1 – Metallic Materials.

D. Calculation of Wall Thickness and Elasticity

1. Minimum wall thickness

1.1 The pipe thicknesses stated in Table 13d.4 to 13d.7 are the assigned minimum thicknesses, unless due to stress analysis, see 2., greater thicknesses are necessary.

Provided that the pipes are effectively protected against corrosion, the wall thicknesses of group M and D stated in Table 13d.5 may, with GL’s agreement, be reduced by up to 1 mm, the amount of the reduction is to be in relation to the wall thickness.

Protective coatings, e.g. hot-dip galvanizing, can be recognized as an effective corrosion protection provided that the preservation of the protective coating during installation is guaranteed.

For steel pipes the wall thickness group corresponding to the location is to be as stated in Table 13d.4.
1.2 The minimum wall thicknesses for austenitic stainless steel pipes are given in Table 13d.6.

1.3 For the minimum wall thickness of air, sounding and overflow pipes through weather decks, see Section 13e, K., Table 13e.4. For CO₂ fire extinguishing pipelines, see Table 13d.8.

1.4 Where the application of mechanical joints results in reduction in pipe wall thickness (bite type rings or other structural elements) this is to be taken into account in determining the minimum wall thickness.

2. Calculation of pipe wall thickness

2.1 The following formula is to be used for calculating the wall thicknesses of cylindrical pipes and bends subject to internal pressure:

\[ s = s_0 + c + b \]

where:

- \( s \) = minimum thickness [mm], see also 2.8
- \( s_0 \) = calculated thickness [mm]
- \( c \) = corrosion allowance [mm], see 2.7
- \( b \) = allowance for bends [mm], see 2.2
- \( p_c \) = design pressure [bar]
- \( d_a \) = outer diameter of pipe [mm]
- \( \sigma_{zul} \) = maximum permissible design stress (see 2.3) [N/mm²]
- \( v \) = weld efficiency factor [-], see 2.6
- \( R \) = bending radius [mm]

2.2 For straight cylindrical pipes which are to be bent, an allowance (b) shall be applied for the bending of the pipes. The value of (b) shall be such that the stress due to the bending of the pipes does not exceed the maximum permissible design stress (\( \sigma_{zul} \)). The allowance (b) can be determined as follows:

\[ b = 0.4 \cdot \left( \frac{d_a}{R} \right) \cdot s_0 \]

2.3 Allowable stress \( \sigma_{zul} \)

2.3.1 Steel pipes

The allowable stress \( \sigma_{zul} \) to be considered in formula (1a) is to be chosen as the lowest of the following values:

- a) design temperature \( \leq 350^\circ C \)
  
  \[ \sigma_{zul} = \min \left\{ \frac{R_{m,20^\circ}}{A}, \frac{R_{eH,t}}{B}, \frac{R_{p_{0.2},t}}{B} \right\} \]

- b) design temperature > 350° C, whereby it is to be checked whether the calculated values according to a) give the decisive smaller value:

\[ R_{m,100000,0} \cdot \frac{B}{B} \]

In the case of pipes which:

- are covered by a detailed stress analysis acceptable to GL and
- are made of material tested by GL, GL may, on special application, agree to a safety factor B of 1.6 (for A and B see Table 13d.10).

2.3.2 Pipes made of metallic materials without a definite yield point

Materials without a definite yield point are covered by Table 13d.9. For other materials, the maximum permissible stress is to be stated with GL agreement, but must be at least

\[ \sigma_{zul} \leq \frac{R_{m,t}}{5} \]

\( R_{m,t} \) is the minimum tensile strength at the design temperature.

2.3.3 The mechanical characteristics of materials which are not included in the GL Rules II – Materials and Welding, Part 1 – Metallic Materials are to be agreed with GL with reference to Table 13d.10.

Steel pipes without guaranteed properties may be used only up to a working temperature of 120° C where the maximum allowable stress \( \sigma_{zul} \leq 80 \text{ N/mm}^2 \) will be approved.

2.3.4 Pipe stress analysis

2.3.4.1 Depending on service conditions, type of flowing media (e.g. sour gas) and loads occurring during piping operation, design and stress calculations including static, dynamic and elasticity analyses have to be performed.
### Table 13d.4 Minimum wall thickness groups N, M and D of steel pipes and approved locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Piping system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery spaces</td>
<td>Hydrant lines</td>
</tr>
<tr>
<td>Cofferds / void spaces</td>
<td>Compressed air lines</td>
</tr>
<tr>
<td>Cargo holds</td>
<td>Fresh cooling water lines</td>
</tr>
<tr>
<td>Ballast water tanks</td>
<td>Drinking water lines</td>
</tr>
<tr>
<td>Fuel and changeover tanks</td>
<td>Feedwater lines</td>
</tr>
<tr>
<td>Fresh cooling water tanks</td>
<td>Condensate lines</td>
</tr>
<tr>
<td>Lubricating tanks</td>
<td>Steam lines</td>
</tr>
<tr>
<td>Hydraulic oil tanks</td>
<td>Thermal lines</td>
</tr>
<tr>
<td>Drinking water tanks</td>
<td>Fuel lines</td>
</tr>
<tr>
<td>Thermal oil tanks</td>
<td>Seawater lines</td>
</tr>
<tr>
<td>Condensate and feedwater tanks</td>
<td>Ballast lines</td>
</tr>
<tr>
<td>Accommodation</td>
<td></td>
</tr>
<tr>
<td>Cargo tanks, tank ships</td>
<td></td>
</tr>
<tr>
<td>Cofferds, tank ships</td>
<td></td>
</tr>
<tr>
<td>Cargo pump rooms</td>
<td></td>
</tr>
<tr>
<td>Weather deck</td>
<td></td>
</tr>
</tbody>
</table>

1. See GL Rules I-1-2, Section 15, B.4.3
2. Seawater discharge lines, see Section 13e, M.
3. Pipelines are not to be installed.
   - Pipelines may be installed after special agreement with GL.
4. Pipelines may be installed after special agreement with GL.

#### 2.3.4.2 Methods of calculation and stress analysis, procedures and the technical data shall be submitted for approval. The change in elasticity of bends and fittings due to deformation shall be taken into consideration. GL reserve the right to perform confirmatory calculations.

For determining the stresses, a calculation shall be applied which conforms to the agreed design code or regulation in force. It is the obligation of the designer to stipulate load cases which cover all relevant operational and environmental influences on the piping.

#### 2.4 Design temperature

**2.4.1** The design temperature is the maximum temperature of the medium inside the pipe. In case of steam pipes, filling pipes from air compressors and starting air lines to internal combustion engines, the design temperature is to be at least 200°C.

**2.4.2** Design temperatures for superheated steam lines are as follows:

a) pipes behind desuperheaters:
   - with automatic temperature control:
     - the working temperature + 15°C
   - with manual temperature control:
     - the working temperature + 15°C

b) pipes before desuperheaters:
   - the working temperature + 15°C

3. Transient excess in the working temperature need not be taken into account when determining the design temperature.
Table 13d.5 Minimum wall thickness for steel pipes

<table>
<thead>
<tr>
<th>da [mm]</th>
<th>s [mm]</th>
<th>da [mm]</th>
<th>s [mm]</th>
<th>da [mm]</th>
<th>s [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,2</td>
<td>1,6</td>
<td>from 406,4</td>
<td>6,3</td>
<td>from 21,3</td>
<td>3,2</td>
</tr>
<tr>
<td>from 13,5</td>
<td>1,8</td>
<td>from 660,0</td>
<td>7,1</td>
<td>from 38,0</td>
<td>3,6</td>
</tr>
<tr>
<td>from 20,0</td>
<td>2,0</td>
<td>from 762,0</td>
<td>8,0</td>
<td>from 51,0</td>
<td>4,0</td>
</tr>
<tr>
<td>from 48,3</td>
<td>2,3</td>
<td>from 864,0</td>
<td>8,8</td>
<td>from 76,1</td>
<td>4,5</td>
</tr>
<tr>
<td>from 70,0</td>
<td>2,6</td>
<td>from 914,0</td>
<td>10,0</td>
<td>from 177,8</td>
<td>5,0</td>
</tr>
<tr>
<td>from 88,9</td>
<td>2,9</td>
<td></td>
<td></td>
<td>from 193,7</td>
<td>5,4</td>
</tr>
<tr>
<td>from 114,3</td>
<td>3,2</td>
<td></td>
<td></td>
<td>from 219,1</td>
<td>5,9</td>
</tr>
<tr>
<td>from 133,0</td>
<td>3,6</td>
<td></td>
<td></td>
<td>from 244,5</td>
<td>6,3</td>
</tr>
<tr>
<td>from 152,4</td>
<td>4,0</td>
<td></td>
<td></td>
<td>from 660,4</td>
<td>7,1</td>
</tr>
<tr>
<td>from 177,8</td>
<td>4,5</td>
<td></td>
<td></td>
<td>from 762,0</td>
<td>8,0</td>
</tr>
<tr>
<td>from 244,5</td>
<td>5,0</td>
<td></td>
<td></td>
<td>from 863,6</td>
<td>8,8</td>
</tr>
<tr>
<td>from 323,9</td>
<td>5,6</td>
<td></td>
<td></td>
<td>from 914,4</td>
<td>10,0</td>
</tr>
</tbody>
</table>

Table 13d.6 Minimum wall thickness for austenitic stainless steel pipes

<table>
<thead>
<tr>
<th>Pipe outside diameter da [mm]</th>
<th>Minimum wall thickness s [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 17,2</td>
<td>1,0</td>
</tr>
<tr>
<td>up to 48,3</td>
<td>1,6</td>
</tr>
<tr>
<td>up to 88,9</td>
<td>2,0</td>
</tr>
<tr>
<td>up to 168,3</td>
<td>2,3</td>
</tr>
<tr>
<td>up to 219,1</td>
<td>2,6</td>
</tr>
<tr>
<td>up to 273,0</td>
<td>2,9</td>
</tr>
<tr>
<td>up to 406,0</td>
<td>3,6</td>
</tr>
<tr>
<td>over 406,0</td>
<td>4,0</td>
</tr>
</tbody>
</table>

Table 13d.7 Minimum wall thickness for copper alloy pipes

<table>
<thead>
<tr>
<th>Pipe outside diameter da [mm]</th>
<th>Minimum wall thickness s [mm]</th>
<th>Copper</th>
<th>Copper alloys</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 – 10</td>
<td>1,0</td>
<td>0,8</td>
<td></td>
</tr>
<tr>
<td>12 – 20</td>
<td>1,2</td>
<td>1,0</td>
<td></td>
</tr>
<tr>
<td>25 – 44,5</td>
<td>1,5</td>
<td>1,2</td>
<td></td>
</tr>
<tr>
<td>50 – 76,1</td>
<td>2,0</td>
<td>1,5</td>
<td></td>
</tr>
<tr>
<td>88,9 – 108</td>
<td>2,5</td>
<td>2,0</td>
<td></td>
</tr>
<tr>
<td>133 – 159</td>
<td>3,0</td>
<td>2,5</td>
<td></td>
</tr>
<tr>
<td>193,7 – 267</td>
<td>3,5</td>
<td>3,0</td>
<td></td>
</tr>
<tr>
<td>273 – 457,2</td>
<td>4,0</td>
<td>3,5</td>
<td></td>
</tr>
<tr>
<td>(470)</td>
<td>4,0</td>
<td>3,5</td>
<td></td>
</tr>
<tr>
<td>508</td>
<td>4,5</td>
<td>4,0</td>
<td></td>
</tr>
</tbody>
</table>

2.5 The design pressure for fuel pipes shall be chosen according to Table 13d.11.

2.6 Weld efficiency factor v

For seamless pipes \( v = 1,0 \)

In the case of welded pipes, the value of \( v \) is to be taken equal to that assigned at the works acceptance test.

2.7 Corrosion allowance c

The corrosion allowance \( c \) depends on the application of the pipe, in accordance with Table 13d.6 and 13d.7. With the agreement of GL, the corrosion allowance of steel pipes effectively protected against corrosion may be reduced by not more than 50 %.

With the agreement of GL, no corrosion allowance need to be applied to pipes made of corrosion-resistant materials (e.g. austenitic steels and copper alloys), see Table 13d.6 and 13d.7.

2.8 Tolerance allowance t

The negative manufacturing tolerances on the thickness according to the standards of the technical terms of delivery are to be added to the calculated wall thickness \( s_0 \) and specified as the tolerance allowance \( t \).

The value of \( t \) may be calculated as follows:

\[
t = s_0 \cdot a / (100 - a) \quad [\text{mm}]
\]

where:

\[
a = \text{negative tolerance on the thickness} \quad [%]
\]

\[
s_0 = \text{calculated wall thickness according to 2.1} \quad [\text{mm}]
\]
Table 13d.8 Minimum steel pipe thickness for CO₂

<table>
<thead>
<tr>
<th>da [mm]</th>
<th>From cylinders to distribution valves s [mm]</th>
<th>From distribution valves to nozzles s [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>21,3 – 26,9</td>
<td>3,2</td>
<td>2,6</td>
</tr>
<tr>
<td>30,0 – 38,3</td>
<td>4,0</td>
<td>3,2</td>
</tr>
<tr>
<td>51,0 – 60,3</td>
<td>4,5</td>
<td>3,6</td>
</tr>
<tr>
<td>63,5 – 76,1</td>
<td>5,0</td>
<td>3,6</td>
</tr>
<tr>
<td>82,5 – 88,9</td>
<td>5,6</td>
<td>4,0</td>
</tr>
<tr>
<td>101,6</td>
<td>6,3</td>
<td>4,0</td>
</tr>
<tr>
<td>108,0 – 114,3</td>
<td>7,1</td>
<td>4,5</td>
</tr>
<tr>
<td>127,0</td>
<td>8,0</td>
<td>4,5</td>
</tr>
<tr>
<td>133,0 – 139,7</td>
<td>8,0</td>
<td>5,0</td>
</tr>
<tr>
<td>152,4 – 168,3</td>
<td>8,8</td>
<td>5,6</td>
</tr>
</tbody>
</table>

Table 13d.9 Allowable stress σₚul for copper and copper alloys (annealed)

<table>
<thead>
<tr>
<th>Pipe material</th>
<th>Minimum tensile strength [N/mm²]</th>
<th>Allowable stress σₚul [N/mm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>215</td>
<td>41 75°C 41 100°C 40 125°C 34 150°C 27,5 175°C 18,5 200°C – 225°C – 250°C – 275°C – 300°C –</td>
</tr>
<tr>
<td>Aluminium brass CuZn20Al</td>
<td>325</td>
<td>78 78 78 78 78 51 24,5 24,5 24,5 24,5 24,5 24,5 24,5 24,5 24,5 24,5 24,5 24,5</td>
</tr>
<tr>
<td>Copper nickel alloys CuNi5Fe</td>
<td>275</td>
<td>68 68 67 65,5 64 62 59 56 52 48 44 44 44 44 44 44 44 44 44</td>
</tr>
<tr>
<td>CuNi10Fe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CuNi30Fe</td>
<td>365</td>
<td>81 79 77 75 73 71 69 67 65,5 64 62</td>
</tr>
</tbody>
</table>

3. Analysis of elasticity

3.1 The forces, moments and stresses caused by impeded thermal expansion and contraction are to be calculated and submitted to GL for approval for the following piping systems:

- steam pipes with working temperatures above 400° C
- pipes with working temperatures below – 110 °C

3.2 Only approved methods of calculation may be applied. The change in elasticity of bends and fittings due to deformation is to be taken into consideration.

Procedure and principles of methods as well as the technical data are to be submitted for approval. GL reserve the right to perform confirmatory calculations.

For determining the stresses, the hypothesis of the maximum shear stress is to be considered. The resulting equivalent stresses due to primary loads, internal pressure and dead weight of the piping system itself (inertia forces) may not exceed the maximum allowable stress according to 2.3. The equivalent stresses obtained by adding together the above-mentioned primary forces and the secondary forces due to impeded expansion or contraction may not exceed the mean low cycle fatigue value or the mean time yield limit in 100 000 hours, whereby for fittings such as bends, T-connections, headers, etc. approved stress increase factors are to be considered.

4. Fittings

Pipe branches may be dimensioned according to the equivalent surface areas method where an appropriate reduction of the maximum allowable stress as specified in 2.3 is to be proposed. Generally, the maximum allowable stress is equal to 70 % of the value according to 2.3 for pipes with diameters over 300 mm. Below this figure, a reduction to 80 % is sufficient. Where detailed stress measuring, calculations or type approvals are available, higher stresses can be permitted.
Table 13d.10 Coefficients A, B for determining the permissible stress \( \sigma_{\text{zul}} \)

<table>
<thead>
<tr>
<th>Material</th>
<th>I</th>
<th>II, III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Unalloyed and alloyed carbon steel</td>
<td>2,7</td>
<td>1,6</td>
</tr>
<tr>
<td>Rolled and forged stainless steel</td>
<td>2,4</td>
<td>1,6</td>
</tr>
<tr>
<td>Steel with yield strength ( &gt; 400 \text{ N/mm}^2 )</td>
<td>3,0</td>
<td>1,7</td>
</tr>
<tr>
<td>Grey cast iron</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Nodular cast iron</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Cast steel</td>
<td>3,2</td>
<td>–</td>
</tr>
</tbody>
</table>

1 Minimum yield strength or minimum 0,2 % proof stress at 20° C.

Table 13d.11 Design pressure for fuel pipes

<table>
<thead>
<tr>
<th>Max. working temperature</th>
<th>T ( \leq 60 °C )</th>
<th>T &gt; 60 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. working pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PB ( \leq 7 ) bar</td>
<td>3 bar or max.</td>
<td>3 bar or max.</td>
</tr>
<tr>
<td></td>
<td>working pressure, whichever is greater</td>
<td>whichever is greater</td>
</tr>
<tr>
<td>PB &gt; 7 bar</td>
<td>max. working</td>
<td>14 bar or</td>
</tr>
<tr>
<td></td>
<td>pressure</td>
<td>max.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>working</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pressure, whichever is greater</td>
</tr>
</tbody>
</table>

\( \sigma_{\text{zul}} \) = allowable stress according to 2.3 for proposed material at design temperature \( t \)

\( \sigma_{\text{zul standard}} \) = allowable stress according to 2.3 for the material at the temperature corresponding to the strength data specified in the standard

\( P_{\text{standard}} \) = nominal pressure PN specified in the standard

6. Design of piping supports and hangers

Piping supports, hangers and other elements to be used for pipe installation have to be designed according to the loads and stresses occurring under piping service and operating conditions.

In case of dynamic loads and/or dynamic events which may occur, the use and design of shock and/or energy absorbers has to be taken in consideration to protect the piping system or other components from any kind of damage.

E. Principles for the Construction of Piping Systems

1. General

1.1 Piping systems shall be constructed and manufactured on the basis of recognized standards.

1.2 Piping intended for use at elevated temperatures has to be rated according to the temperature limitation of respective standards or specifications.

1.3 Welding shall be done according to the applicable technical requirements and state-of-the-art workmanship and good practice. The welding documentation, welding preparation and weld joints shall be checked and inspected by GL as necessary during fabrication and after completion of welding heat treatment. For further details see GL Rules II – Materials and Welding.

1.4 Welded joints rather than detachable couplings shall be used for all hydrocarbon services, for piping carrying toxic media, flammable liquefied gases as well as for pipes for superheated steam with temperatures exceeding 400 °C.

1.5 Expansion in piping systems due to heating and shifting of their suspensions caused by deformations of the adjacent structure shall be compensated by bends, compensators and flexible pipe connections. The arrangement of suitable fixed points shall be taken into consideration.

1.6 Where pipes are protected against corrosion by special protective coatings, e.g. hot dip galvanising, rubber lining, etc., it is to be ensured that the protective coating will not be damaged during installation.
Table 13d.12  Corrosion allowance c for carbon steel pipes

<table>
<thead>
<tr>
<th>Type of piping system</th>
<th>Corrosion allowance c [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superheated steam lines</td>
<td>0,3</td>
</tr>
<tr>
<td>Saturated steam lines</td>
<td>0,8</td>
</tr>
<tr>
<td>Steam heating coils inside cargo tanks</td>
<td>2,0</td>
</tr>
<tr>
<td>Feedwater lines:</td>
<td></td>
</tr>
<tr>
<td>in closed circuit systems</td>
<td>0,5</td>
</tr>
<tr>
<td>in open circuit systems</td>
<td>1,5</td>
</tr>
<tr>
<td>Boiler blowdown lines</td>
<td>1,5</td>
</tr>
<tr>
<td>Compressed air lines</td>
<td>1,0</td>
</tr>
<tr>
<td>Hydraulic oil lines, lubricating oil lines</td>
<td>0,3</td>
</tr>
<tr>
<td>Fuel lines</td>
<td>1,0</td>
</tr>
<tr>
<td>Cargo oil lines</td>
<td>2,0</td>
</tr>
<tr>
<td>Refrigerant lines for Group 1 refrigerants</td>
<td>0,3</td>
</tr>
<tr>
<td>Refrigerant lines for Group 2 refrigerants</td>
<td>0,5</td>
</tr>
<tr>
<td>Seawater lines</td>
<td>3,0</td>
</tr>
<tr>
<td>Fresh water lines</td>
<td>0,8</td>
</tr>
</tbody>
</table>

Table 13d.13  Corrosion allowance c for non-ferrous metals

<table>
<thead>
<tr>
<th>Pipe material</th>
<th>Corrosion allowance c [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper, brass and similar alloys</td>
<td></td>
</tr>
<tr>
<td>Copper-tin alloys except those containing lead</td>
<td>0,8</td>
</tr>
<tr>
<td>Copper-nickel alloys (with Ni ≥ 10 %)</td>
<td>0,5</td>
</tr>
</tbody>
</table>

2.  Pipe connections

2.1  Types of connection

The following pipe connections may be used:

- full penetration butt welds with/without provision to improve the quality of the root
- socket welds with suitable fillet weld thickness and where appropriate in accordance with recognized standards
- steel flanges may be used in accordance with the permitted pressures and temperatures specified in the relevant standards

- mechanical joints (e.g. pipe unions, pipe couplings, press fittings) of an approved type

For the use of welded pipe connections, see Table 13d.14.

2.2  Flange connections

2.2.1  Dimensions of flanges and bolting shall comply with recognized standards.

2.2.2  Gaskets are to be suitable for the intended media under design pressure and temperature conditions and their dimensions and construction shall be in accordance with recognized standards.

2.2.3  Steel flanges may be used as shown in Table 13d.18 and 13d.19 in accordance with the permitted pressures and temperatures specified in the relevant standards.

2.2.4  Flanges made of non-ferrous metals may be used in accordance with the relevant standards and within the limits laid down in the approvals. Flanges and brazed or welded collars of copper and copper alloys are subject to the following requirements:

a) welding neck flanges according to standard up to 200 °C or 300 °C according to the maximum temperatures indicated in Table 13d.9; applicable to all classes of pipe

b) loose flanges with welding collar; as for a) c) plain brazed flanges: only for pipe class III up to a nominal pressure of 16 bar and a temperature of 120 °C

c) plain brazed flanges: only for pipe class III up to a nominal pressure of 16 bar and a temperature of 120 °C.

2.2.5  Flange connections for pipe classes I and II with temperatures over 300 °C are to be provided with necked-down bolts.

2.3  Welded socket connections

Welded socket connections may be accepted according to Table 13d.14. Following conditions are to be observed:

- The thickness of the sockets is to be in accordance with D.1.1 at least equal to the thickness of the pipe.
- The clearance between the pipes and the socket is to be as small as possible.
- The use of welded socket connections in systems of pipe class II may be accepted only under the condition that in the systems no excessive stress, erosion and corrosion are expected.

2.4  Screwed socket connections

2.4.1  Screwed socket connections with parallel and tapered threads shall comply with requirements of recognized national or international standards.
2.4.2 Screwed socket connections with parallel threads are permitted for pipes in class III with an outside diameter \( \leq 60.3 \) mm as well as for subordinate systems (e.g. sanitary and hot water heating systems). They are not permitted for systems for flammable media.

2.4.3 Screwed socket connections with tapered threads are permitted for the following:

- class I, outside diameter not more than 33.7 mm
- class II and class III, outside diameter not more than 60.3 mm

Screwed socket connections with tapered threads are not permitted for piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.

Table 13d.14 Pipe connections

<table>
<thead>
<tr>
<th>Types of connections</th>
<th>Pipe class</th>
<th>Outside diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welded butt-joints with special provisions for root side</td>
<td>I, II, III</td>
<td>all</td>
</tr>
<tr>
<td>Welded butt-joints without special provisions for root side</td>
<td>II, III</td>
<td></td>
</tr>
<tr>
<td>Socket weld</td>
<td>III</td>
<td>II ( \leq 60.3 ) mm</td>
</tr>
</tbody>
</table>

2.5 Brazed connections

Brazed connections may be used after special approval by GL.

2.6 Mechanical joints

2.6.1 Type approved mechanical joints \(^4\) may be used as shown in Table 13d.15 to 13d.17.

2.6.2 Mechanical joints in bilge and seawater systems within machinery spaces or spaces of high fire risk, e.g. cargo pump rooms and car decks, shall be flame resistant.

2.6.3 Mechanical joints are not to be used in piping sections directly connected to sea openings or tanks containing flammable liquids.

2.6.4 The use of slip-on joints is not permitted in:

- bilge lines inside ballast and fuel tanks
- seawater and ballast lines including air and overflow pipes inside cargo holds and fuel tanks
- fuel and oil lines including air and overflow pipes inside machinery spaces, cargo holds and ballast tanks
- non water filled pressure water spraying systems (dry pipe systems)

Slip-on joints inside tanks may be permitted only if the pipes contain the same medium as the tanks.

Unrestrained slip on joints may be used only where required for compensation of lateral pipe movement.

2.7 Layout, marking and installation

2.7.1 Piping systems shall be adequately identified according to their purpose. Valves are to be permanently and clearly marked.

2.7.2 Pipe penetrations leading through bulkheads/decks and tank walls shall be water and oil tight. Bolts through bulkheads are not permitted. Holes for fastening screws shall not be drilled in the tank walls.

2.7.3 Sealing systems for pipes penetrating through watertight bulkheads and decks as well as through fire divisions are to be approved by GL unless the pipe is welded into the bulkhead/deck \(^5\).

2.7.4 Piping close to electrical switchboards shall be so installed or protected that a leakage cannot damage the electrical installation.

2.7.5 Piping systems are to be so arranged that they can be completely emptied, drained and vented. Piping systems in which the accumulation of liquids during operation could cause damage shall be equipped with special drain arrangements.

2.7.6 Pipe lines laid through ballast tanks, which are coated are to be either effectively protected against corrosion or they are to be of low susceptibility to corrosion.

The method of corrosion protection of tanks and pipes shall be compatible.

2.7.7 The wall thickness of pipes between unit’s side and first shut-off device is to be in accordance with Section 13e, Table 13e.4, column B. Pipes are to be connected by welding or flanges.

2.8 Shut-off devices

For the requirements of shut-off devices including remote control of valves see Section 13c.

2.9 Valves on the shell plating

2.9.1 For the mounting of valves on the shell plat- ing, see GL Rules I – Ship Technology, Part 1 – Sea- going Ships, Chapter 1 – Hull Structures, Section 6, G.

\(^4\) See also GL “List of Type Tested Appliances and Equipment”

\(^5\) VI – Additional Rules and Guidelines, Part 7 – Guidelines for the Performance of Type Approvals, Chapter 4 – Test Requirements for Sealing Systems of Bulkhead and Deck Penetrations.
2.9.2 Valves on the shell plating shall be easily accessible. Seawater inlet and outlet valves shall be capable of being operated from above the floor plates.

Cocks on the shell plating shall be so arranged that the handle can only be removed when the cock is closed.

2.9.3 Valves with only one flange may be used on the shell plating and on the sea chests only after special approval.

2.9.4 On units in periodically unattended machinery spaces, the controls of sea inlet and discharge valves shall be sited so as to allow to reach and operate sea inlet and discharge valves in case of influx of water within 10 minutes (compare special flag state requirements) after triggering of the bilge alarm.

Non return discharge valves need not to be considered.

3. Hose assemblies and compensators

3.1 Scope

3.1.1 The following requirements are applicable for hose assemblies and compensators made of non-metallic and metallic materials.

3.1.2 Hose assemblies and compensators made of non-metallic and metallic materials may be used according to their suitability in fuel-, lubricating oil-, hydraulic oil-, bilge-, ballast-, fresh water cooling-, sea water cooling-, compressed air-, auxiliary steam 6, exhaust gas and thermal oil systems as well as in secondary piping systems.

3.1.3 Hose assemblies and compensators made of non-metallic materials are not permitted in permanently pressurized starting air lines. Furthermore it is not permitted to use hose assemblies and compensators in fuel injection piping systems of combustion engines.

3.1.4 Compensators made of non-metallic materials are not approved for the use in cargo lines of FPSO/FSO/FPO.

3.2 Definitions

Hose assemblies consist of metallic or non-metallic hoses completed with end fittings ready for installation.

Compensators consist of bellows with end fittings as well as anchors for absorption of axial loads where angular or lateral flexibility is to be ensured. End fittings may be flanges, welding ends or approved pipe unions. Burst pressure is the internal static pressure at which a hose assembly or compensator will be destroyed.

3.2.1 High-pressure hose assemblies made of non-metallic materials

Hose assemblies which are suitable for use in systems with distinct dynamic load characteristics.

3.2.2 Low-pressure hose assemblies and compensators made of non-metallic materials

Hose assemblies or compensators which are suitable for use in systems with predominant static load characteristics.

3.2.3 Maximum allowable working pressure respectively nominal pressure of hose assemblies and compensators made of non-metallic materials

3.2.3.1 The maximum allowable working pressure of high pressure hose assemblies is the maximum dynamic internal pressure permitted to be imposed on the components.

3.2.3.2 The maximum allowable working pressure respectively nominal pressure for low pressure hose assemblies and compensators is the maximum static internal pressure permitted to be imposed on the components.

3.2.4 Test pressure

3.2.4.1 For non-metallic high pressure hose assemblies the test pressure is 2 times the maximum allowable working pressure.

3.2.4.2 For non-metallic low pressure hose assemblies and compensators the test pressure is 1.5 times the maximum allowable working pressure or 1.5 times the nominal pressure.

3.2.4.3 For metallic hose assemblies and compensators the test pressure is 1.5 times the maximum allowable working pressure or 1.5 times the nominal pressure.

3.2.5 Burst pressure

For non-metallic as well as metallic hose assemblies and compensators the burst pressure is to be at least 4 times the maximum allowable working pressure or 4 times the nominal pressure. Excepted hereof are non-metallic hose assemblies and compensators with a maximum allowable working pressure or nominal pressure of not more than 20 bar. For such components the burst pressure has to be at least three times the maximum allowable working pressure or three times the nominal pressure.

For hose assemblies and compensators in process and cargo piping for gas operation the burst pressure is required to be at least 5 times the maximum allowable working pressure.
### Table 13d.15 Examples of mechanical joints

<table>
<thead>
<tr>
<th><strong>Pipe Unions</strong></th>
<th>![Image]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welded and brazed type</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Compression Couplings</strong></th>
<th>![Image]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swage type</td>
<td>![Image]</td>
</tr>
<tr>
<td>Press type</td>
<td>![Image]</td>
</tr>
<tr>
<td>Bite type</td>
<td>![Image]</td>
</tr>
<tr>
<td>Flared type</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Slip-on Joints</strong></th>
<th>![Image]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip type</td>
<td>![Image]</td>
</tr>
<tr>
<td>Machine grooved type</td>
<td>![Image]</td>
</tr>
<tr>
<td>Slip type</td>
<td>![Image]</td>
</tr>
<tr>
<td>Systems</td>
<td>Pipe Unions</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Flammable fluids (Flash point &lt; 60° C)</strong></td>
<td></td>
</tr>
<tr>
<td>Cargo oil</td>
<td>+</td>
</tr>
<tr>
<td>Crude oil washing</td>
<td>+</td>
</tr>
<tr>
<td>Vent</td>
<td>+</td>
</tr>
<tr>
<td><strong>Inert gas</strong></td>
<td></td>
</tr>
<tr>
<td>Water seal effluent</td>
<td>+</td>
</tr>
<tr>
<td>Scrubber effluent</td>
<td>+</td>
</tr>
<tr>
<td>Main</td>
<td>+</td>
</tr>
<tr>
<td>Distributions</td>
<td>+</td>
</tr>
<tr>
<td><strong>Flammable fluids (Flash point &gt; 60° C)</strong></td>
<td></td>
</tr>
<tr>
<td>Cargo oil</td>
<td>+</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>+</td>
</tr>
<tr>
<td>Lubricating oil</td>
<td>+</td>
</tr>
<tr>
<td>Hydraulic oil</td>
<td>+</td>
</tr>
<tr>
<td>Thermal oil</td>
<td>+</td>
</tr>
<tr>
<td><strong>Sea Water</strong></td>
<td></td>
</tr>
<tr>
<td>Bilge</td>
<td>+</td>
</tr>
<tr>
<td>Fire main and water spray</td>
<td>+</td>
</tr>
<tr>
<td>Foam</td>
<td>+</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>+</td>
</tr>
<tr>
<td>Ballast</td>
<td>+</td>
</tr>
<tr>
<td>Cooling water</td>
<td>+</td>
</tr>
<tr>
<td>Tank cleaning</td>
<td>+</td>
</tr>
<tr>
<td>Non-essential</td>
<td>+</td>
</tr>
<tr>
<td><strong>Fresh Water</strong></td>
<td></td>
</tr>
<tr>
<td>Cooling water system</td>
<td>+</td>
</tr>
<tr>
<td>Condensate return</td>
<td>+</td>
</tr>
<tr>
<td>Non-essential system</td>
<td>+</td>
</tr>
<tr>
<td><strong>Sanitary / Drains Scruppers</strong></td>
<td></td>
</tr>
<tr>
<td>Deck drains (internal)</td>
<td>+</td>
</tr>
<tr>
<td>Sanitary drains</td>
<td>+</td>
</tr>
<tr>
<td>Scruppers and discharge (overboard)</td>
<td>+</td>
</tr>
<tr>
<td><strong>Sounding / Vent</strong></td>
<td></td>
</tr>
<tr>
<td>Water tanks / Dry spaces</td>
<td>+</td>
</tr>
<tr>
<td>Oil tanks (F.p. &gt; 60° C)</td>
<td>+</td>
</tr>
</tbody>
</table>
### Table 13d.16 Application of mechanical joints (continued)

<table>
<thead>
<tr>
<th>Miscellaneous</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting-/Control air&lt;sup&gt;1&lt;/sup&gt;</td>
<td>+</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Service air (non-essential)</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Brine</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>CO&lt;sub&gt;2&lt;/sub&gt; system&lt;sup&gt;1&lt;/sup&gt;</td>
<td>+</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Steam</td>
<td>+</td>
<td>+</td>
<td>−</td>
</tr>
</tbody>
</table>

**Abbreviations:**
- + Application is allowed
- − Application is not allowed

**Footnotes:**
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 freeboard 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.

---

### Table 13d.17 Application of mechanical joints depending upon the class of piping

<table>
<thead>
<tr>
<th>Types of joints</th>
<th>Classes of piping systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td><strong>Pipe Unions</strong></td>
<td></td>
</tr>
<tr>
<td>Welded and brazed type</td>
<td>+</td>
</tr>
<tr>
<td>(da &lt; 60.3 mm)</td>
<td></td>
</tr>
<tr>
<td><strong>Compression Couplings</strong></td>
<td></td>
</tr>
<tr>
<td>Swage type</td>
<td>+</td>
</tr>
<tr>
<td>Press type</td>
<td>−</td>
</tr>
<tr>
<td>Bite type</td>
<td>+</td>
</tr>
<tr>
<td>(da &lt; 60.3 mm)</td>
<td></td>
</tr>
<tr>
<td>Flared type</td>
<td>+</td>
</tr>
<tr>
<td>(da &lt; 60.3 mm)</td>
<td></td>
</tr>
<tr>
<td><strong>Slip-on Joints</strong></td>
<td></td>
</tr>
<tr>
<td>Machinery grooved type</td>
<td>+</td>
</tr>
<tr>
<td>Grip type</td>
<td>−</td>
</tr>
<tr>
<td>Slip type</td>
<td>−</td>
</tr>
</tbody>
</table>
Table 13d.18 Use of flange types for non-hydrocarbon services

<table>
<thead>
<tr>
<th>Pipe class</th>
<th>Toxic, corrosive and combustible media, liquefied gasses (LG)</th>
<th>Steam, thermal oils</th>
<th>Lubricating oil, fuel oil</th>
<th>Other media</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PR [bar]</td>
<td>Temperature [°C]</td>
<td>Type of flange</td>
<td>Temperature [°C]</td>
</tr>
<tr>
<td>I</td>
<td>&gt; 10</td>
<td>A</td>
<td>&gt; 400</td>
<td>A, B</td>
</tr>
<tr>
<td></td>
<td>≤ 10</td>
<td>A, B</td>
<td>≤ 400</td>
<td>A, B</td>
</tr>
<tr>
<td>II</td>
<td>–</td>
<td>A, B, C</td>
<td>&gt; 250</td>
<td>A, B, C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤ 250</td>
<td>A, B, C, D, E</td>
</tr>
<tr>
<td>III</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>A, B, C, D, E</td>
</tr>
</tbody>
</table>

1 Type B only for outside diameter dₐ < 150 mm
2 Type E only for t < 150 °C and PR < 16 bar
3 Type F only for water pipes and open-ended lines

3.3 Requirements

3.3.1 Hoses and compensators used in the systems mentioned in 3.1.2 are to be of an approved type.  

3.3.2 Manufacturers of hose assemblies and compensators shall be recognized by GL.

3.3.3 Hose assemblies and compensators including their couplings are to be suitable for media, pressures and temperatures they are designed for.

3.3.4 The selection of hose assemblies and compensators is to be based on the maximum allowable working pressure of the system concerned. A pressure of 5 bar is to be considered as the minimum working pressure.

3.3.5 Hose assemblies and compensators for the use in fuel-, lubricating oil-, hydraulic oil-, bilge- and sea water systems are to be flame-resistant.

3.4 Installations

3.4.1 Hose assemblies and compensators shall only be used at locations where they are required for compensation of relative movements. They shall be kept as short as possible under consideration of the installation instructions of the hose manufacturer. The number of hose assemblies and compensators is to be kept to a minimum.

3.4.2 The minimum bending radius of installed hose assemblies shall not be less than specified by the manufacturers.

3.4.3 Non-metallic hose assemblies and compensators are to be located at visible and accessible positions.

3.4.4 In fresh water systems with a working pressure of ≤ 5 bar and in charging and scavenging air lines, hoses may be fastened to the pipe ends with double clips.

3.4.5 Where hose assemblies and compensators are installed in the vicinity of hot components they shall be provided with approved heat-resistant sleeves.

3.4.6 Hose assemblies and compensators conveying flammable liquids that are in close proximity of heated surfaces are to be provided with screens or other similar protection to avoid the risk of ignition due to failure at the hose assembly or compensator.

3.5 Test

3.5.1 Hose assemblies and compensators are to be subjected in the manufacturer’s works to a pressure test in accordance with 3.2.4 under the supervision of GL.

3.5.2 For compensators intended to be used in exhaust gas pipes the pressure test according 3.5.1 may be omitted.

3.6 Cargo hoses

3.6.1 Cargo hoses for handling of gas shall be of an approved type.  

Mounting of end fittings is to be carried out only by approved manufacturers.
3.6.2 Cargo hoses are to be subjected to final inspection at the manufacturer under supervision of a GL-Surveyor as follows:

− visual inspection
− hydrostatic pressure test with 1.5 times the maximum allowable working pressure or 1.5 times the nominal pressure. The nominal pressure shall be at least 10 bar.
− measuring of the electrical resistance between the end fittings. The resistance shall not exceed 1 k\(^\Omega\).

3.7 Marking

Hose assemblies and compensators shall be permanently marked with the following particulars:

− manufacturer's mark or symbol
− date of manufacturing
− type
− nominal diameter
− maximum allowable working pressure respectively nominal pressure
− test Certificate number and identification code of the responsible GL inspection office

4. Protection of piping systems against over-pressure

The following piping systems shall be fitted with safety valves to avoid destructive overpressures:

- a) Piping systems and valves in which liquids can be blocked in and heated;
- b) Piping systems which may be exposed to service pressures in excess of the design pressure.

Safety valves shall be capable of discharging at a maximum pressure increase of 10 % above the maximum allowable overpressure. Safety valves shall be fitted on the low pressure side of reducing valves. See also Section 13c - Valves.

5. Protection of piping systems against vibrations

Protective means to reduce the reactions caused by reciprocating pumps in hydrocarbon services are outlined in Section 11, C.1.2, see also B.2.1.6.
Table 13d.19 Types of flange connection

<table>
<thead>
<tr>
<th>Type A</th>
<th>Type B</th>
<th>Type C</th>
<th>Type D</th>
<th>Type E</th>
<th>Type F</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Welding neck flange" /></td>
<td><img src="image2" alt="Slip-on welding flange - fully welded" /></td>
<td><img src="image3" alt="Slip-on welding flange" /></td>
<td><img src="image4" alt="Socket screwed flange" /></td>
<td><img src="image5" alt="Plain flange" /></td>
<td><img src="image6" alt="Lap joint flange" /></td>
</tr>
<tr>
<td>Welding neck flange</td>
<td>Slip-on welding flange - fully welded</td>
<td>Slip-on welding flange</td>
<td>Socket screwed flange</td>
<td>Plain flange</td>
<td>Lap joint flange</td>
</tr>
<tr>
<td><img src="image7" alt="Loose flange with welding neck" /></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loose flange with welding neck</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section 13e

Piping Systems for Specific Services

A. General

1. Scope

This Section defines the special requirements for a series of specific applications of piping systems within specific services for operation of the unit/installation excluding the production process.

2. References

The general principles for pipe design are defined in Section 13d. Special requirements are given for tanks in Section 13a, for pumps in Section 13b and for valves in Section 13c.

The requirements for drilling and production piping systems are defined in Section 13f.

B. Steam Piping System

1. Operation

1.1 Steam lines are to be so laid out and arranged that essential consumers can be supplied with steam from every main boiler as well as from a stand-by boiler or boiler for emergency operation.

1.2 Essential consumers are:

− all consumers essential for the propulsion, manoeuvrability and safe operation of the unit as well as the essential auxiliary machines according to Section 1, H.

− all consumers necessary to the safety of the unit or installation

1.3 Every steam consumer shall be capable of being shut off from the steam system.

2. Calculation of pipelines

2.1 Steam lines and valves are to be constructed for the design pressure PR according to Section 13d, B.2.2.4.

2.2 Calculations of pipe thickness and analysis of elasticity in accordance with Section 13d are to be carried out. Sufficient compensation for thermal expansion is to be proven.

3. Laying out of steam lines

3.1 Steam lines are to be so installed and supported that expected stresses due to thermal expansion, external loads and shifting of the supporting structure under both normal and interrupted service conditions will be safely compensated.

3.2 Steam lines are to be so installed that water pockets will be avoided.

3.3 Means are to be provided for the reliable drainage of the piping system.

3.4 Steam lines are to be effectively insulated to prevent heat losses.

3.4.1 At points where there is a possibility of contact, the surface temperature of the insulated steam lines may not exceed 80 °C.

3.4.2 Wherever necessary, additional protection arrangements against unintended contact are to be provided.

3.4.3 The surface temperature of steam lines in the pump rooms of FPSO/FSO may nowhere exceed 220 °C.

3.5 Steam heating lines, except for heating purposes, are not to be led through accommodation.

3.6 Sufficiently rigid positions are to be arranged as fixed points for the steam piping systems.

3.7 It is to be ensured that the steam lines are fitted with sufficient expansion arrangements.

3.8 Where a system can be supplied from a system with higher pressure, it is to be provided with reducing valves and with relief valves on the low pressure side.

3.9 Welded connections in steam lines are subject to the requirements specified in the Rules II – Materials and Welding, Part 3 – Welding.

4. Steam strainers

Wherever necessary, machines and apparatus in steam systems are to be protected against foreign matter by steam strainers.
5. Steam connections to equipment and pipes carrying oil, e.g. steam atomizers or steam-out arrangements, are to be so secured that fuel and oil cannot penetrate into the steam lines.

6. Inspection of steam lines for expanding
Steam lines for superheated steam at above 500 °C are to be provided with means of inspecting the pipes for expanding. This can be in the form of measuring sections on straight length of pipes at the superheater outlet preferably. The length of these measuring sections is to be at least 2 . dₚ.

C. Boiler Feed Water and Circulating Arrangements, Condensate Recirculation

1. Feed water pumps
1.1 At least two separate feedwater pumps shall be provided for each boiler installation.

For those services not essential for the safety of the installation/unit, only one feed water system is required if automatic shutdown of the steam generating system upon loss of the feed water supply is provided.

1.2 Feed water pumps shall be so arranged or equipped that no backflow of water can occur when the pumps are at standstill.

1.3 Feed water pumps shall be used only for feeding boilers.

2. Capacity of feed water pumps
2.1 Where two feed water pumps are provided, the capacity of each shall be equivalent to at least 1,25 times the maximum permitted output of all the connected steam generators.

2.2 Where more than two feed water pumps are installed, the capacity of all other feed water pumps in the event of the failure of the pump with the largest capacity shall comply with the requirements of 2.1.

2.3 For continuous flow boilers the capacity of each feed water pump shall be at least 1,0 times the maximum steam output of all connected steam generators.

2.4 Special requirements may be approved for the capacity of the feed water pumps for plants incorporating a combination of oil fired and exhaust gas boilers.

3. Delivery pressure of feed water pumps
Feed water pumps shall be so designed, that they can satisfy the following requirements:

a) The required capacity according to 2. shall be achieved against the maximum allowable working pressure of the steam producer.

b) The safety valves shall have a capacity equal to 1,0 times the approved steam output at 1,1 times the allowable working pressure.

The resistances to flow in the piping between the feed water pump and the boiler shall be taken into account. In the case of continuous flow boilers the resistance of the boiler shall additionally be taken into account.

4. Power supply to feed water pumps
4.1 At least two independent power sources shall be available for the operation of feed water pumps.

4.2 For steam-driven feed water pumps, the supply of all the pumps from only one steam system is allowed, provided that all the steam producers are connected to this steam system. Where feed water pumps are driven solely by steam, a suitable filling and start up pump, independent of steam supply, shall be provided.

4.3 For electric drives, a separate supply cable from the common bus-bar to each pump motor is sufficient.

5. Feed water lines

5.1 General
5.1.1 Feed water lines may not pass through tanks which do not contain feed water.

5.1.2 Each feed water line is to be fitted with a shut-off valve and a check valve at the boiler inlet. Where the shut-off valve and the check valve are not directly connected in series, the intermediate pipe is to be fitted with a drain.

5.1.3 Continuous flow boilers need not be fitted with the valves required according to 5.1.2 provided that the heating of the boiler is automatically switched off should the feed water supply fail, and that the feed water pump supplies only one boiler.

5.2 Feed water lines for auxiliary steam generators (auxiliary and exhaust gas boilers)

5.2.1 The provision of only one feed water line for auxiliary and exhaust gas boilers is sufficient, if the preheaters and automatic regulating devices are fitted with by-pass lines.

5.2.2 The requirements in 5.1.2 are to apply as appropriate to the valves required to be fitted to the boiler inlet.

5.2.3 Continuous flow boilers need not be fitted with the valves required according to 5.1.2 provided that the heating of the boiler is automatically switched off should the feed water supply fail, and that the feed water pump supplies only one boiler.

6. Boiler water circulating systems
6.1 Each forced-circulation boiler shall be equipped with two circulating pumps powered independently of each other. Failure of the circulating pump in operation is to be signalled by an alarm. The alarm may only be switched off if a circulating pump is started or when the boiler firing is shut down.
6.2 The provision of only one circulating pump for each boiler is sufficient if
  a) the boilers are heated only by gases whose temperature does not exceed 400 °C, or
  b) a common stand-by circulating pump is provided which can be connected to any boiler, or
  c) the burners of oil or gas fired auxiliary boilers are so arranged that they are automatically shut off should the circulating pump fail and the heat stored in the boiler does not cause any unacceptable evaporation of the available water in the boiler.

7. Feed water supply, evaporators
7.1 The feed water supply is to be stored in several tanks.
7.2 One storage tank may be considered sufficient for auxiliary boiler units.
7.3 Two evaporators shall be provided for main steam generator units.

8. Condensate recirculation
8.1 The main condenser shall be equipped with two condensate pumps, each of which shall be able to transfer the maximum volume of condensate produced.
8.2 The condensate of all heating systems used to heat oil (fuel, lubricating, cargo oil, etc.) shall be led to condensate observation tanks. These tanks shall be fitted with air vents.
8.3 Heating coils of tanks containing fuel or oil residues, e.g. sludge tanks, leak oil tanks, bilge water tanks, etc. are to be provided at the tank outlet with shut-off devices for testing the condensate for the presence of oil.

D. Fuel Oil Systems
1. Bunker lines
The bunkering of oil fuels shall be effected by means of permanently installed lines either from the open deck or from bunkering stations located below deck which shall be isolated from other spaces.

Bunker stations are to be arranged so that they are automatically shut off should the bunkering line fail and the heat stored in the boiler does not cause any unacceptable evaporation of the available water in the boiler.

2. Tank filling lines
2.1 Filling lines of fuel tanks, which are led into the tanks below the tank top, are to be fitted with remote controlled shut-off valves. It shall be possible to operate the remote controlled shut-off valves from a compartment accessible at all times and separate from the compartment where the fuel tanks are located.

2.2 Where filling lines are led through the tank top, a screw-down non-return valve at the tank top is sufficient.
Filling lines shall extend close to the bottom of the tank.

Storage tank suction lines may also be used as filling lines.

3. Suction lines
3.1 Suction lines from tanks provided in ship-shaped units, situated above the double bottom, shall be fitted directly at the tank wall with remote controlled shut-off valves which can be closed from an adjacent compartment or deck above, which is accessible at all times.

Shut-off devices on fuel oil tanks having a capacity of less than 500 l need not be provided with remote control.

3.2 The inlet connections of suction lines shall be arranged far enough from the drains in the tank, so that water and impurities which have settled out will not enter the suction lines.

4. Pipe layout
4.1 Fuel lines may not pass through tanks containing feed water, drinking water, lubricating oil or thermal oil.

4.2 Fuel lines which pass through ballast tanks shall have an increased wall thickness according to Section 13d, Table 13d.4.

4.3 Fuel lines may not be laid directly above or in the vicinity of boilers, turbines or equipment with high surface temperatures (over 220 °C) or in way of other sources of ignition.

4.4 Flanged and screwed socket connections in fuel oil lines shall 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 other sources of ignition.

The number of detachable pipe connections is to be limited. In general, flanged connections according to recognized standards shall be used.

4.5 Flanged and screwed socket connections in fuel oil lines which lay directly above hot surfaces or other sources of ignition are to be screened and provided with drainage arrangements.

4.6 Flanged and screwed socket connections in fuel oil lines with a maximum allowable working pressure of more than 0.18 N/mm² and within about 3 m from hot surfaces or other sources of ignition and direct sight of line shall be screened. Drainage arrangements need not to be provided.
4.7 Flanged and screwed socket connections in fuel oil lines with a maximum allowable working pressure of less than 0.18 N/mm² and within about 3 m from hot surfaces or other sources of ignition shall be assessed individually taking into account working pressure, type of coupling and possibility of failure.

4.8 Flanged and screwed socket connections in fuel oil lines with a maximum allowable working pressure of more than 1.6 N/mm² need normally to be screened.

4.9 Pipes running below engine room floor need normally not be screened.

4.10 Shut-off valves in fuel lines in the machinery spaces shall be operable from above the floor plates.

4.11 Glass and plastic components are not permitted in fuel systems. Sight glasses made of glass located in vertical overflow pipes may be permitted.

4.12 Fuel pumps shall be capable of being isolated from the piping system by shut-off valves.

5. Fuel transfer, feed and booster pumps

5.1 Fuel transfer, feed and booster pumps shall be designed for the proposed operating temperature of the medium.

5.2 A fuel transfer pump shall be provided. Other service pumps may be used if they are suitable for this purpose.

5.3 At least two means of oil fuel transfer shall be provided for filling the service tanks.

5.4 Where a feed or booster pump is required to supply fuel to main or auxiliary engines, a standby pumps shall be provided. Where, in the case of auxiliary engines, the pumps are attached to the engine, a standby pump may be dispensed with.

Other arrangements require the approval of GL.

6. Plants with more than one main engine

For plants with more than one engine, complete spare feed or booster pumps stored on board may be accepted instead of stand-by pumps provided that the feed or booster pumps are so arranged that they can be replaced with the means available on board.

7. Shut-off devices

7.1 On units of 500 gross tonnage or above for plants with more than one engine shut-off devices for isolating the fuel supply and overproduction/recirculation lines to any engine from a common supply system shall be provided. These valves shall be operable from a position not rendered inaccessible by a fire on any of the engines.

7.2 Instead of shut-off devices in the overproduction/recirculation lines check valves may be fitted. Where shut-off devices are fitted, they are to be locked in the operating position.

8. Filters

8.1 Fuel oil filters are to be fitted in the delivery line of the fuel pumps.

8.2 For units with Class Notation AUT the filter equipment shall satisfy the requirements of the GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 4 – Automation, Section 2.

8.3 Mesh size and filter capacity are to be in accordance with the requirements of the manufacturer of the engine.

8.4 Uninterrupted supply of filtered fuel has to be ensured during cleaning of the filtering equipment. In case of automatic back-flushing filters it is to be ensured that a failure of the automatic back-flushing will not lead to a total loss of filtration.

8.5 Back-flushing intervals of automatic back-flushing filters provided for intermittent back-flushing are to be monitored.

8.6 Fuel oil filters are to be fitted with differential pressure monitoring. On engines provided for operation with gas oil only, differential pressure monitoring may be dispensed with.

8.7 Engines for the exclusive operation of emergency generators and emergency fire pumps may be fitted with simplex filters.

8.8 Fuel transfer units are to be fitted with a simplex filter on the suction side.

8.9 For filter arrangement, see Section 3, G.3.

9. Purifiers

9.1 Manufacturers of purifiers for cleaning fuel and lubricating oil shall be approved by GL.

9.2 Where a fuel purifier may exceptionally be used to purify lubricating oil the purifier supply and discharge lines are to be fitted with a change-over arrangement which prevents the possibility of fuel and lubricating oils being mixed.

Suitable equipment is also to be provided to prevent such mixing occurring over control and compression lines.

9.3 The sludge tanks of purifiers are to be fitted with a level alarm which ensures that the level in the
sludge tank cannot interfere with the operation of the purifier.

10. Service tanks

10.1 On units of 500 gross tonnage or above two fuel oil service tanks for each type of fuel necessary for propulsion and vital systems are to be provided. Equivalent arrangements may be permitted.

10.2 Each service tank shall have a capacity of at least 8 hours at maximum continuous rating of the propulsion plant and normal operation load of the generator plant.

11. Heavy fuel oils

When heavy fuels are to be used, appropriate heating arrangements shall be provided, see GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 11, G.

E. Lubricating Oil Systems

1. General requirements

1.1 Lubricating oil systems are to be so constructed to ensure reliable lubrication over the whole range of speed and during run-down of the engines and to ensure adequate heat transfer.

1.2 Priming pumps

Where necessary, priming pumps are to be provided for supplying lubricating oil to the engines.

1.3 Emergency lubrication

A suitable emergency lubricating oil supply (e.g. gravity tank) is to be arranged for machinery which may be damaged in case of interruption of lubricating oil supply.

1.4 Lubricating oil treatment

1.4.1 Equipments necessary for adequate treatment of lubricating oil such as purifiers, automatic back-flushing filters, filters and free-jet centrifuges are to be provided.

1.4.2 In the case of auxiliary engines running on heavy fuel which are supplied from a common lubricating oil tank, suitable equipment is to be fitted to ensure that in case of failure of the common lubricating oil treatment system or ingress of fuel or cooling water into the lubricating oil circuit, the auxiliary engines required to safeguard the power supply in accordance with Chapter 6 – Electrical Installations remain fully operational.

2. Lubricating oil systems

2.1 Lubricating oil circulating tanks and gravity tanks

2.1.1 For the capacity and location of these tanks see Section 13a, D.

2.1.2 Where an engine lubricating oil circulation tank extends to the bottom shell plating on units for which a double bottom is required in the engine room, shut-off valves are to be fitted in the drain pipes between engine casing and circulating tank. These valves are to be capable of being closed from a level above the lower platform.

2.1.3 The suction connections of lubricating oil pumps are to be located as far as possible from drain pipes.

2.1.4 Gravity tanks are to be fitted with an overflow pipe which leads to the circulating tank. Arrangements are to be made for observing the flow of excess oil in the overflow pipe.

2.2 Filling and suction lines

2.2.1 Filling and suction lines of lubricating oil tanks with a capacity of 500 l and more located above the double bottom and from which in case of their damage lubricating oil may leak, are to be fitted directly on the tanks with shut-off devices according to D.2. The remote operation of shut-off valves according to D.2.may be dispensed with:

- for valves which are kept closed during normal operation
- where an unintended operation of a quick closing valve would endanger the safe operation of the main propulsion plant or essential auxiliary machinery

2.2.2 Where lubricating oil lines shall be led in the vicinity of hot machinery, e.g. superheated steam turbines, steel pipes which should be in one length and which are protected where necessary are to be used.

2.2.3 For screening arrangements of lubricating oil pipes D.4.4 applies as appropriate.

2.3 Filters

2.3.1 Lubricating oil filters are to be fitted in the delivery line of the lubricating oil pumps.

2.3.2 Mesh size and filter capacity are to be in accordance with the requirements of the manufacturer of the engine.

2.3.3 Uninterrupted supply of filtered lubricating oil has to be ensured under cleaning conditions of the filter equipment. In case of automatic back-flushing
2.3.4 Back-flushing intervals of automatic back-flushing filters provided for intermittent back-flushing are to be monitored.

2.3.5 Main lubricating oil filters are to be fitted with differential pressure monitoring. On engines provided for operation with gas oil only, differential pressure monitoring may be dispensed with.

2.3.6 Engines for the exclusive operation of emergency generators and emergency fire pumps may be fitted with simplex filters.

2.3.7 For protection of the lubricating oil pumps simplex filters may be installed on the suction side of the pumps if they have a minimum mesh size of 100 μ.

2.3.8 For the arrangement of filters, see Section 3, G.3.

2.4 Lubricating oil coolers

It is recommended that turbine and large engine plants be provided with more than one oil cooler.

2.5 Oil level indicators

Machines with their own oil charge are to be provided with a means of determining the oil level from outside during operation. This requirement also applies to reduction gears, thrust bearings and shaft bearings.

2.6 Purifiers

The requirements in D.9. apply as appropriate.

3. Lubricating oil pumps

3.1 Main engines

3.1.1 Main and independent stand-by pumps are to be arranged.

Main pumps driven by the main engines are to be so designed that the lubricating oil supply is ensured over the whole range of operation.

3.1.2 For plants with more than one main engine, see Section 3, G.4.2.3.

3.2 Main turbine plant

3.2.1 Main and independent stand-by lubricating oil pumps are to be provided.

3.2.2 Emergency lubrication

The lubricating oil supply to the main turbine plant for cooling the bearings during the run-down period is to be assured in the event of failure of the power supply. By means of suitable arrangements such as gravity tanks the supply of oil is also to be assured during starting of the emergency lubrication system.

3.3 Main reduction gearing (motor units)

3.3.1 Lubricating oil is to be supplied by a main pump and an independent stand-by pump.

3.3.2 Where a reduction gear has been approved by GL to have adequate self-lubrication at 75 % of the torque of the propelling engine, a stand-by lubricating oil pump for the reduction gear may be dispensed with up to a power-speed ratio of

\[ P/n_l \leq 3.0 \]

\( n_l \) = gear input revolution \([\text{min}^{-1}]\)

3.3.3 The requirements under 3.1.2 are to be applied for multi-propeller plants and plants with more than one engine.

3.4 Auxiliary machinery

3.4.1 Diesel generators

Where more than one diesel generator is available, stand-by pumps are not required. Where only one diesel generator is available (e.g. on turbine-driven units where the diesel generator is needed for start-up, etc.) a complete spare pump is to be carried on board.

3.4.2 Auxiliary turbines

Turbogenerators and turbines used for driving important auxiliaries such as boiler feed water pumps, etc. are to be equipped with a main pump and an independent auxiliary pump. The auxiliary pump is to be designed to ensure a sufficient supply of lubricating oil during the start-up and run-down operation.

F. Seawater Cooling and Supply Systems

1. Sea suctions, sea chests

1.1 At least two sea chests are to be provided. Wherever possible, the sea chests are to be arranged as low as possible on either side of the unit.

1.2 For service in shallow waters, it is recommended that an additional high seawater intake is provided.

1.3 It is to be ensured that the total seawater supply for the engines can be taken from only one sea chest.

1.4 Each sea chest is to be provided with an effective vent. The following venting arrangements will be approved:
− an air pipe of at least 32 mm ID which can be shut off and which extends above the bulkhead deck
− adequately dimensioned ventilation slots in the shell plating

1.5 Steam or compressed air connections are to be provided for clearing the sea chest gratings. The steam or compressed air lines are to be fitted with shut-off valves fitted directly to the sea chests. Compressed air for blowing through sea chest gratings may exceed 2 bar only if the sea chests are constructed for higher pressures.

1.6 For fixed installations and elevated units special measures have to be provided to deliver the seawater to the topside. This equipment may be integrated into the legs/jackets or a special suction tower may be installed. For self-elevating units this tower has also to be movable up and down.

2. Special rules for units with ice Class

For special rules for units with ice Class see GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 11, I.2.

3. Sea valves

3.1 Sea valves are to be so arranged that they can be operated from above the floor plates.

3.2 Discharge pipes for seawater cooling systems are to be fitted with a shut-off valve at the shell.

4. Strainer

The suction lines of the seawater pumps are to be fitted with strainers.

The strainers are to be so arranged that they can be cleaned during service.

Where cooling water is supplied by means of a scoop, strainers in the main seawater cooling line can be dispensed with.

5. Pumps

5.1 Diesel engine plants

5.1.1 Main propulsion plants are to be provided with main and stand-by cooling water pumps.

5.1.2 The main cooling water pump may be attached to the propulsion plant. It is to be ensured that the attached pump is of sufficient capacity for the cooling water required by main engines and auxiliary equipment over the whole speed range of the propulsion plant.

The drive of the stand-by cooling water pump is to be independent of the main engine.

5.1.3 Main and stand-by cooling water pumps are each to be of sufficient capacity to meet the maximum cooling water requirements of the plant.

Alternatively, three cooling water pumps of the same capacity and delivery head may be arranged, provided that two of the pumps are sufficient to supply the required cooling water for full load operation of the plant.

With this arrangement it is permissible for the second pump to be automatically put into operation only in the higher temperature range by means of a thermostat.

5.1.4 Ballast pumps or other suitable seawater pumps may be used as stand-by cooling water pumps.

5.1.5 Submersible seawater lift pumps on fixed installations shall be inserted in, or attached to, the suction tubing to allow easy removal for control and maintenance. They have to be installed deep enough to minimize the oxygen content of seaweeds, mud or disposed liquids.

5.2 Turbine plants

For turbine plants the requirements will be agreed between Owner/Operator, turbine manufacturer and GL.

5.3 Plants with more than one main engine

For plants with more than one engine and with separate cooling water systems, complete spare pumps stored on board may be accepted instead of stand-by pumps provided that the main seawater cooling pumps are so arranged that they can be replaced with the means available on board.

5.4 Cooling water supply for auxiliary engines

Where a common cooling water pump is provided to serve more than one auxiliary engine, an independent stand-by cooling water pump with the same capacity is to be fitted. Independently operated cooling water pumps of the main engine plant may be used to supply cooling water to auxiliary engines while at sea, provided that the capacity of such pumps is sufficient to meet the additional cooling water requirement.

If each auxiliary engine is fitted with an attached cooling water pump, stand-by cooling water pumps need not to be provided.

G. Freshwater Cooling Systems

1. General

1.1 Fresh water cooling systems are to be so arranged that the engines can be sufficiently cooled under all operating conditions.
1.2 Depending on the requirements of the engine plant, the following fresh water cooling systems are allowed:
- a single cooling circuit for the entire plant
- separate cooling circuits for the main and auxiliary plant
- several independent cooling circuits for the main engine components which need cooling (e.g. cylinders, pistons and fuel valves) and for the auxiliary engines
- separate cooling circuits for various temperature ranges

1.3 The cooling circuits are to be so divided that, should one part of the system fail, operation of the auxiliary systems can be maintained. Change-over arrangements are to be provided for this purpose if necessary.

1.4 As far as possible, the temperature controls of main and auxiliary engines as well as of different circuits are to be independent of each other.

1.5 Where, in automated engine plants, heat exchangers for fuel or lubricating oil are incorporated in the cylinder cooling water circuit of main engines, the entire cooling water system is to be monitored for fuel and oil leakage.

1.6 Common engine cooling water systems for main and auxiliary plants are to be fitted with shut-off valves to enable repairs to be performed without taking the entire plant out of service.

2. Heat exchangers, coolers

2.1 The construction and equipment of heat exchangers are subject to the requirements of Section 12c.

2.2 The coolers of cooling water systems, engines and equipment are to be so designed to ensure that the specified cooling water temperatures can be maintained under all operating conditions. Cooling water temperatures are to be adjusted to meet the requirements of engines and equipment.

2.3 Heat exchangers for auxiliary equipment in the main cooling water circuit are to be provided with by-passes if, in the event of a failure of the heat exchanger, it is possible by these means to keep the system in operation.

2.4 It is to be ensured that auxiliary machinery can be maintained in operation while repairing the main coolers. If necessary, means are to be provided for changing over to other heat exchangers, machinery or equipment through which a temporary heat transfer can be achieved.

2.5 Shut-off valves shall be provided at the inlet and outlet of all heat exchangers.

2.6 Each heat exchanger shall be provided with a vent and a drain.

2.7 Keel coolers, box coolers

2.7.1 Arrangement and construction drawings of keel and box coolers are to be submitted for approval.

2.7.2 Permanent vents for fresh water are to be provided at the top of keel coolers and chest coolers.

2.7.3 Keel coolers are to be fitted with pressure gauge connections at the fresh water inlet and outlet.

3. Expansion tanks

3.1 Expansion tanks shall be arranged at sufficient height for each cooling water circuit. Different cooling circuits may only be connected to one common expansion tank, if they do not interfere with each other. Care shall be taken here to ensure that damage to or faults in one system cannot affect the other system.

3.2 Expansion tanks shall be fitted with filling connections, aeration/de-aeration devices, water level indicators and a drain arrangement.

4. Fresh water cooling pumps

4.1 Main and stand-by cooling water pumps are to be provided for each fresh water cooling system.

4.2 Main cooling water pumps may be driven directly by the main or auxiliary engines which they are intended to cool provided that a sufficient supply of cooling water is assured under all operating conditions.

4.3 The drives of stand-by cooling water pumps are to be independent of the main engines.

4.4 Stand-by cooling water pumps are to have the same capacity as main cooling water pumps.

4.5 Main engines are to be fitted with at least one main and one stand-by cooling water pump. Where according to the construction of the engines more than one water cooling circuit is necessary, a stand-by pump is to be fitted for each main cooling water pump.

4.6 For fresh cooling water pumps of essential auxiliary engines the requirements for sea water cooling pumps in F. may be applied.
4.7 A stand-by cooling water pump of a cooling water system may be used as a stand-by pump for another system provided that the necessary pipe connections are arranged. The shut-off valves in these connections are to be secured against unintended operation.

4.8 Equipment providing emergency cooling from another system can be approved if the plant and the system are suitable for this purpose.

4.9 For plants with more than one main engine the requirements for sea cooling water pumps in F. may be applied.

5. Temperature control
Cooling water circuits shall be provided with temperature control and alarms. Control devices, whose failure may impair the functional reliability of the machinery, shall be equipped with means for manual operation.

6. Preheating of cooling water
Means shall be provided for preheating fresh cooling water. Exceptions are to be approved by GL.

7. Emergency generator units

7.1 Internal combustion engines driving emergency generators or fire pumps shall be fitted with independent cooling systems.

7.2 Such cooling systems shall be protected from freezing, where necessary.

H. Bilge Pumping Arrangements

1. General
An efficient bilge pumping system shall be provided, capable of pumping from and/or draining watertight compartments other than spaces permanently appropriated for the carriage of fresh water, water ballast, oil fuel or liquid cargo and for which other efficient means of pumping are provided, under all practical conditions whether the unit is upright or inclined as specified in Section 1, C. Additional suction shall be provided in large compartments or compartments of unusual form, as deemed necessary by GL. Arrangements shall be made whereby water in the compartment may find its way to the suction pipes. Compartments not provided with bilge suction may be drained to other spaces provided with bilge pumping capability. Means shall be provided to detect the presence of water in such compartments, which are adjacent to the sea or adjacent to tanks containing liquids, and in void compartments through which pipes conveying liquids pass. If GL is satisfied that the safety of the unit is not impaired, the bilge pumping arrangements and the means to detect the presence of water may be dispensed with in particular compartments.

2. Pumps

2.1 At least two self-priming power pumps connected to each bilge main shall be provided, one of which shall be designated exclusively as a bilge pump.

2.2 Ballast pumps, stand-by seawater cooling pumps and general service pumps may also be used as independent bilge pumps provided they are self-priming and of the required capacity according to 14.1.

2.3 In the event of failure of one of the required bilge pumps, one pump each shall be available for fire fighting and bilge pumping.

2.4 Fuel and oil pumps may not be connected to the bilge system.

2.5 Bilge ejectors are acceptable as bilge pumping arrangements provided that there is an independent supply of driving water.

3. Bilge pipes
All bilge pipes shall be of steel or other suitable materials having properties acceptable to GL. Special consideration shall be given to the design of bilge lines passing through ballast tanks, taking into account effects of corrosion or other deterioration.

4. Entrance of water
The arrangement of the bilge pumping system shall be such as to prevent the possibility of water passing from the sea into dry spaces, or inadvertently from one compartment to another.

5. Arrangement of distribution boxes and valves
All distribution boxes and manually operated valves in connection with the bilge pumping arrangements shall be arranged in positions which are accessible under ordinary circumstances. Where such valves are located in normally unmanned spaces below the assigned load line and not provided with high bilge water level alarms, they shall be operable from outside the space.

6. Position of valves
A means to indicate whether a valve is open or closed shall be provided at each location from which the valve can be controlled. The indicator shall rely on movement of the valve spindle.

7. Drainage
Drainage of hazardous areas shall be given special consideration having regard to the risk of explosion. Piping systems for those areas shall be designed to
preclude direct communication between hazardous areas of different classifications, and between hazardous and non-hazardous areas.

8. Column stabilized units

The following additional requirements are applicable to column stabilized units:

8.1 Chain lockers which, if flooded, could substantially affect the unit’s stability shall be provided with a remote means to detect flooding and a permanently installed means of dewatering. Remote indication of flooding shall be provided at the central ballast control station.

8.2 At least one of the pumps referred to in 2. and the pump room bilge suction valves shall be capable of both remote and local operation.

8.3 Propulsion rooms and pump rooms in lower hulls shall be provided with two independent systems for high bilge water level detection providing an audible and visual alarm at the central ballast control station.

9. Bilge suctions and strums

9.1 Bilge suctions are to be so arranged as not to impede the cleaning of bilges and bilge wells. They are to be fitted with easily detachable, corrosion resistant strums.

9.2 Emergency bilge suctions are to be arranged such that they are accessible, with free flow and at a suitable distance from the tank top or the unit’s bottom.

9.3 Bilge wells shall have a capacity of more than 0.2 m³. Small spaces may have smaller bilge wells. Bilge wells are to be separated from the shell.

10. Bilge valves

10.1 Valves in connecting pipes between the bilge and the seawater and ballast water system, as well as between the bilge connections of different compartments, shall be so arranged that even in the event of faulty operation or intermediate positions of the valves, penetration of seawater through the bilge system will be safely prevented.

10.2 Bilge discharge pipes shall be fitted with shut-off valves at the unit’s shell.

10.3 Bilge valves are to be arranged so as to be always accessible irrespective of the ballast and load condition of the unit.

11. Reverse-flow protection

11.1 A screw-down non-return valve is recognized as reverse-flow protection.

11.2 A combination of a non-return valve without positive means of closing and a shut-off valve are recognized as reverse flow protection.

12. Pipe connections

12.1 To prevent the penetration of ballast and seawater through the bilge system, two means of reverse-flow protection shall be fitted in the bilge connections. One such means of protection shall be fitted in each suction line.

12.2 The direct bilge suction and the emergency suction need only to have one means of reverse-flow protection.

12.3 The discharge pipes of oily water separators shall be fitted with two non-return valves at the shell plating.

12.4 Where a direct seawater connection is arranged for attached bilge pumps to protect them against dry running, the bilge suctions are also to be fitted with two reverse flow protecting devices.

13. Calculation of pipe diameters

13.1 The cross sectional area of the main bilge pipe shall be at least equal to the sum of the cross sectional areas of the two largest branch pipes.

13.2 The internal diameter of bilge suction from each compartment shall not be less than

\[ d_{\text{min}} = 2.15 \cdot A^{0.5} + 25 \text{ [mm]} \]

Internal diameter of any bilge line is not to be less than 50 mm.

A = wetted surface [m²] of the compartment in question excluding stiffing members, when it is halfway filled with water.

14. Capacity of bilge pumps

14.1 Each bilge pump shall be capable of delivering not less than

\[ Q = 5.75 \cdot 10^{-3} \cdot d_h^2 \text{ [m³/h]} \]

\[ Q = \text{minimum capacity [m³/h]} \]

\[ d_h = \text{calculated inside diameter of main bilge pipe [mm]} \]

14.2 Where centrifugal pumps are used for bilge pumping, they shall be self-priming or connected to an air extracting device.
14.3 One bilge pump of a smaller capacity than that required according to 14.1 is acceptable provided that the other pump is designed for a correspondingly larger capacity. However, the capacity of the smaller bilge pump shall not be less than 85% of the calculated capacity.

15. Arrangement of pipes

15.1 Bilge pipes shall comply with the requirements in Section 13d, D. and Table 13d.4.

15.2 The site and location of bilge wells shall be determined so as to avoid the spreading of water over large areas.

15.3 Machinery spaces

15.3.1 On units of more than 100 gross tonnage, the bilges of every main machinery space shall be capable of being pumped simultaneously as follows:
   a) through the bilge suctions connected to the main bilge system
   b) through one direct suction connected to the largest independent bilge pump
   c) through an emergency bilge suction connected to the sea cooling water pump of the main propulsion plant or through another suitable emergency bilge system

15.3.2 If the unit's propulsion plant is located in several spaces, a direct suction in accordance with 15.3.1 b) is to be provided in each watertight compartment in addition to branch bilge suctions in accordance with 15.3.1 a).

When the direct suctions are in use, it shall be possible to pump simultaneously from the main bilge line by means of all the other bilge pumps.

The diameter of the direct suction may not be less than that of the main bilge pipe.

15.4 Shaft tunnel

A bilge suction is to be arranged at the aft end of the shaft tunnel. Where the shape of the bottom or the length of the tunnel requires, an additional bilge suction is to be provided at the forward end. Bilge valves for the shaft tunnel are to be arranged outside the tunnel in the engine room.

15.5 Cargo holds

15.5.1 Cargo holds are to be normally fitted with bilge suctions fore and aft.

15.5.2 Cargo holds having a length under 30 m may be provided with only one bilge suction on each side.

15.5.3 On units with only one cargo hold, bilge wells are to be provided fore and aft.

15.6 Spaces above fore and aft peaks

These spaces shall either be connected to the bilge system or are to be drained by means of hand pumps.

Spaces located above the aft peak may be drained to the shaft tunnel or to the engine room bilge, provided the drain line is fitted with a self-closing valve which is to be located at a highly visible and accessible position. The drain lines shall have a diameter of at least 40 mm.

15.7 Cofferdams, pipe tunnels and void spaces

Cofferdams, pipe tunnels and void spaces adjoining the unit's shell are to be connected to the bilge system.

Where the aft peak is adjoining the engine room, it may be drained over a self-closing valve to the engine room bilge.

For cofferdams, pipe tunnels and void spaces located above the deepest load water line equivalent means may be accepted by GL after special agreement.

15.8 Chain lockers

Chain lockers are to be drained by means of appropriate arrangements.

15.9 Condensate drain tanks of charge air coolers

If condensate from a drain tank of a charge air cooler shall be pumped overboard directly or indirectly, the discharge line is to be provided with an approved 15 ppm alarm. If the oil content exceeds 15 ppm an alarm is to be released and the pump shall stop automatically.

The 15 ppm alarm is to be arranged so that the bilge pump will not be stopped during bilge pumping from engine room to overboard.

Additionally the tank is to be provided with a connection to the oily water separator.

16. Oily water separating equipment

Platforms and drill ships shall be provided with a oily water separator or filter plant for the separation of water/oil mixtures.

For the outfitting with oily water separators, filter plants, oil collecting tanks and oil discharge pipes, and with a system for monitoring and controlling the discharge of water from oily water separators, attention is drawn to the need to comply with the provisions of the International Convention of 1973 and of the Protocol of 1978 for the prevention of pollution from ships, "MARPOL", as amended.
I. Ballast Pumping Arrangements

1. Ballast lines

1.1 Layout of ballast systems

1.1.1 Column stabilized units or drill ships shall be provided with an efficient pumping system capable of ballasting and deballasting the system under all conditions. Gravity ballasting may be permitted after special consideration by GL.

1.1.2 The ballast system shall be capable of operation after damage as specified in 3.5.3 of the IMO MODU Code, and shall have the capability of restoring the unit to a level trim and safe draught condition without taking on additional ballast, with any one pump inoperable. Counter-flooding may be permitted after special consideration by GL.

1.1.3 The ballast system shall be arranged and operated so as to prevent inadvertent transfer of ballast water from one tank or hull to another, which could result in moment shifts leading to excessive angles of heel or trim.

1.2 Ballast lines through tanks

Ballast lines through tanks in the columns of semi-submersible units shall be designed for an external pressure which equals to at least the design pressure of the tank.

Ballast water pipes may not pass through drinking water, feed water, thermal oil, fuel oil or lubrication oil tanks.

Special consideration shall be given to the design of ballast lines passing through ballast tanks, taking into account for effects of corrosion or other deterioration.

1.3 Piping

1.3.1 Suctions in ballast water tanks are to be so arranged, that the tanks can be emptied despite unfavourable conditions of trim and list.

1.3.2 Adequate compensation for the expansion in the ballast lines shall be arranged by bends or approved expansion joints.

1.3.3 Non-metallic expansion joints in working areas below the water line shall be flame-resistant.

1.3.4 All ballast pipes shall be of steel or other suitable material having properties acceptable to GL.

1.3.5 All valves and operating controls shall be clearly marked to identify the function they serve. Means shall be provided locally to indicate whether a valve is open or not.

1.3.6 Air pipes shall be provided on each ballast tank in sufficient number and cross-sectional area to permit efficient operation of the ballast pumping system under the conditions referred to in K.

In order to allow deballasting of the ballast tanks intended to be used to bring the unit back to normal draught and to ensure no inclination after damage, air pipe openings of these tanks shall be above the worst damage water line specified. Such air pipes shall be positioned outside the assumed extent of damage, see Chapter 2, Section 7, F.

1.3.7 For the dimensioning of the ballast lines, the requirements of Section 13d, D. and Table 13d.4 have to be considered.

2. Ballast pumps

2.1 Number of ballast pumps

2.1.1 At least two independent ballast pumps shall be provided so that the ballast system remains operational in the event of failure of any such pump.

2.1.2 Other sea water pumps may be used as ballast pumps provided that they are readily available for such use at all times.

2.2 Capacity of ballast pumps

With the ballast pumps operating simultaneously, it shall be capable to bring the unit, while in an intact condition, from the maximum normal operating draught to a severe storm draught, or to a greater distance, as may be specified by GL, within 3 hours.

2.3 Power supply for ballast pumps

It shall be possible to supply each ballast pump from the emergency source of power. The arrangement shall be such that the system is capable of restoring the unit from an inclination of 15 degrees in any direction to a level trim and safe draught condition after loss of any single component in the power supply system.

3. Control and monitoring

3.1 The tank level indicating system shall provide means to:

- indicate liquid levels in all ballast tanks. A secondary means of determining levels in ballast tanks, which may be a sounding pipe, shall be provided. Tank level sensors shall not be situated in the tank suction lines.

- indicate liquid levels in other tanks, such as fuel oil, fresh water, drilling water or liquid storage tanks, the filling and emptying of which, in the view of GL, could effect the stability of the unit. Tank level sensors shall not be situated in tank suction lines.
3.2 The draught indicating system shall indicate the draught at each corner of the unit or at representative positions as required by GL.

3.3 The requirements for control and monitoring are defined in Chapter 6, Section 12, J.

4. Internal communication
The intercom link between all relevant control positions is defined in Chapter 6, Section 12, J.5.

5. Testing
See Chapter 6 – Electrical Installations, Section 12, J.6.

J. Thermal Oil Systems

1. Pumps

1.1 Circulating pumps
Two circulating pumps independent of each other shall be provided.

1.2 Transfer pumps
A transfer pump shall be installed for filling the expansion tank and for draining the system.

1.3 The pumps shall be so mounted that any oil leakage can be safely disposed of.

2. Valves

2.1 Only valves made of ductile materials may be used.

2.2 Valves shall be designed for a nominal pressure of not less than PN 16.

2.3 Valves shall be mounted in accessible positions.

2.4 Non-return valves shall be fitted in the discharge lines of the pumps.

2.5 Valves in return pipes shall be secured in the open positions.

2.6 Bellow sealed valves are to be preferably used.

3. Piping

3.1 Pipes in accordance with Section 13d, Table 13d.1 shall be used.

3.2 The material of the gaskets shall be suitable for permanent operation at the design temperature and resistant to the thermal oil.

3.3 Provisions shall be made for thermal expansions by an appropriate pipe layout and the use of suitable compensators.

3.4 The piping shall be preferably connected by welding. The number of detachable pipe connections shall be minimized.

3.5 The laying of pipes through accommodation, public or service spaces is not permitted.

3.6 Piping passing through operational areas shall be installed in such a way that it is protected against damage.

3.7 Pipe penetrations through bulkheads and decks shall be insulated against conduction of heat.

3.8 The venting shall be so arranged that air/oil mixtures can be safely disposed of. Bleeder screws are not permitted.

3.9 For screening arrangements of thermal oil pipes D.4.4 applies as appropriate.

4. Drainage and storage tanks

4.1 Drainage and storage tanks shall be equipped with air pipes and drains. For storage tanks see also Section 13a.

4.2 The air pipes for the drainage tanks shall terminate above open deck. For air pipe closing devices see K.1.3.

4.3 Drains shall be self-closing if the tanks are located above double bottom.

5. Pressure testing
See Section 13d, C.4.

6. Tightness and operational testing
After installation, the entire arrangement is to be subjected to tightness and operational testing under the supervision of GL.

K. Air, Overflow and Sounding Pipes

General
The laying of air, overflow and sounding pipes is permitted only in places where the laying of the corresponding piping system is also permitted, see Section 13d, Table 13d.4.
For special strength requirements regarding fore deck fittings, see GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 1 – Hull Structures, Section 21, E.5.

1. Air and overflow pipes

1.1 Arrangement

1.1.1 All tanks, void spaces, etc. shall be fitted at their highest position with air pipes or overflow pipes. Air pipes shall normally terminate at the open deck.

1.1.2 Air and overflow pipes shall be laid vertically.

1.1.3 Air and overflow pipes passing through operating areas shall be protected against damage.

1.1.4 For the height above deck of air/overflow pipes and the necessity of fitting brackets on air pipes, see GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 1 – Hull Structures, Section 21, E.

The wall thickness of air pipes on the exposed deck shall be in accordance with Table 13e.3 and 13e.4.

1.1.5 Air pipes from unheated leakage oil tanks and lubricating oil tanks may terminate at clearly visible positions in the engine room. Where these tanks form part of the unit's hull, the air pipes are to terminate above the freeboard deck. It shall be ensured that no leaking oil can spread onto heated surfaces where it may ignite.

1.1.6 Air pipes from lubricating oil tanks and leakage oil tanks which terminate in the engine room are to be provided with funnels and pipes for safe drainage in the event of possible overflow.

1.1.7 On units of 500 gross tonnage or above air pipes of lubricating oil tanks which terminate on open deck are to be arranged such that in the event of a broken air pipe this shall not directly lead to the risk of ingress of sea or rainwater.

1.1.8 Wherever possible, the air pipes of feed water and distillate tanks should not extend into the open. Where these tanks form part of the unit's shell the air pipes are to terminate within the engine room casing above the freeboard deck.

1.1.9 Air pipes for cofferdams and void spaces with bilge connections are to be extended above the open deck.

1.1.10 On units of 500 gross tonnage or above air pipes of fuel service and settling tanks which terminate on open deck are to be arranged such that in the event of a broken air pipe this shall not directly lead to the risk of ingress of sea or rainwater.

1.1.11 Where fuel service tanks are fitted with change-over overflow pipes, the change-over devices are to be so arranged that the overflow is led to one of the storage tanks.

1.1.12 The overflow pipes of changeable tanks shall be capable of being separated from the fuel overflow system.

1.1.13 Where the air and overflow pipes of several tanks situated at the unit's shell lead to a common line, the connections to this line are to be above the freeboard deck, as far as practicable but at least so high above the deepest load waterline that should a leakage occur in one tank due to damage to the hull or listing of the unit, fuel or water cannot flow into another tank.

1.1.14 The air and overflow pipes of lubricating oil and fuel tanks shall not be led to a common line.

1.1.15 For the cross-sectional area of air pipes and air/overflow pipes, see Table 13e.1.

Table 13e.1 Cross-sectional area of air and overflow pipes

<table>
<thead>
<tr>
<th>Tank filling systems</th>
<th>Cross-sectional areas of air and overflow pipes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LR</td>
</tr>
<tr>
<td>filling mode</td>
<td>by gravity</td>
</tr>
<tr>
<td></td>
<td>by pumping</td>
</tr>
</tbody>
</table>

Explanatory note:

LR = air pipe
LÜR = air-/overflow pipe
f = cross-sectional area of tank filling pipe

¹ 1.25 f as the total cross-sectional areas is sufficient if it can be proved that the resistance to flow of the air and overflow pipes including the air pipe closing devices at the proposed flow rate cannot cause unacceptable high pressures in the tanks in the event of overflow.

1.2 Number of air and overflow pipes

1.2.1 The number and arrangement of the air pipes is to be so performed that the tanks can be aerated and deaerated without exceeding the tank design pressure by over- or underpressure.

1.2.2 Tanks which extend from side to side of the unit shall be fitted with an air/overflow pipe at each side. At the narrow ends of double bottom tanks in the forward and aft parts of the unit, only one air/overflow pipe is sufficient.
1.3 Air pipe closing devices

Air/overflow pipes terminating above the open deck are to be fitted with approved air pipe heads. To prevent blocking of the air pipe head openings by their floats during tank discharge the maximum allowable air velocity determined by the manufacturer is to be observed.

1.4 Overflow systems

1.4.1 Ballast water tanks

Proof by calculation is to be provided for the system concerned that under the specified operating conditions the design pressures of all the tanks connected to the overflow system cannot be exceeded.

1.4.2 Fuel oil tanks

The requirements to be met by overflow systems of heavy oil tanks are specified in V1 – Additional Rules and Guidelines, Part 3 – Machinery Installations, Chapter 6 – Guidelines for Construction, Equipment and Testing of Closed Fuel Overflow Systems.

1.4.3 The overflow collecting manifolds of fuel tanks are to be led at a sufficient gradient to an overflow tank of sufficient capacity.

The overflow tank is to be fitted with a level alarm which operates when the tank is about 1/3 full.

1.4.4 For the size of the air and overflow pipes, see Table 13e.2.

1.4.5 The use of a fuel storage tank as overflow tank is permissible but requires the installation of a high level alarm and an air pipe with 1,25 times the cross-sectional area of the main bunkering line.

1.5 Determination of the pipe cross-sectional areas

1.5.1 For the cross-sectional areas of air and overflow pipes, see Tables 13e.1 and 13e.2.

Air and overflow pipes shall have an outside diameter of at least 60,3 mm.

On units greater 80 m in length in the forward quarter only air/overflow pipes with an outer diameter ≥ 76,1 mm may be used, see also GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 1 – Hull Structures, Section 21.

1.6 Minimum wall thickness

The minimum wall thickness of air and overflow pipes are to be in accordance with Table 13e.3 and 13e.4, whereby A, B and C are the groups for the minimum wall thickness.

1.7 The pipe materials are to be selected according to Section 13d, C.2.

2. Sounding pipes

2.1 General

2.1.1 Sounding pipes shall be provided for tanks, cofferdams and void spaces with bilge connections and for bilges and bilge wells in spaces which are not accessible at all times.

On application, the provision of sounding pipes for bilge wells in permanently accessible spaces may be dispensed with.

2.1.2 Where the tanks are fitted with remote level indicators which are type-approved by GL, the arrangement of sounding pipes can be dispensed with.

2.1.3 As far as possible, sounding pipes shall be laid straight and shall extend near to the bottom of the tank.

2.1.4 Sounding pipes, which terminate below the deepest operation waterline of the unit, shall be fitted with self-closing shut-off devices. Such sounding pipes are only permissible in spaces which are accessible at all times.

All other sounding pipes shall be extended to the open deck. The sounding pipe openings must always be accessible and fitted with watertight closures.

2.1.5 Sounding pipes of tanks shall be provided close to the top of the tank with holes for equalising the pressure.

2.1.6 Sounding pipes passing through operational holds are to be laid in protected spaces or they are to be protected against damage.

2.2 Sounding pipes for fuel, lubricating oil and thermal oil tanks

2.2.1 Sounding pipes which terminate below the open deck shall be provided with self-closing devices as well as with self-closing test valves.

2.2.2 Sounding pipes shall not be located in the vicinity of fired plants, machine components with high surface temperatures or electrical equipment.

2.2.3 Sounding pipes shall not terminate in accommodation or service spaces.

2.2.4 Sounding pipes shall not be used as filling pipes.

2.3 Cross section of pipes

2.3.1 Sounding pipes shall have a nominal inside diameter of at least 32 mm.
### Table 13e.2 Dimensions of vent and overflow pipes (closed overflow systems)

<table>
<thead>
<tr>
<th>Tank filling and overflow systems</th>
<th>Cross-sectional areas air and overflow pipes</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LR</td>
<td>ÜR</td>
</tr>
</tbody>
</table>
| Filling                          |     |     |     | cross-sectional area of stand-pipe $\geq 1,25 F$ (
| Stand-pipe                      | $\frac{1}{3} f$ | $-$ | $-$ |                                  |
| Relief valve                     | $\frac{1}{3} f$ | min. $1,25 F$ | $-$ | cross-sectional area of stand-pipe $\geq 1,25 F$ |
| Overflow system                  |     |     |     |                            |
| Overflow chest                   | $\frac{1}{3} F$ at chest | min. $1,25 F$ | $1,25 F$ |                                  |
| Manifold                         | $\frac{1}{3} F$ | min. $1,25 F$ | $-$ |                                  |
| Overflow tank                    | $\frac{1}{3} F$ | $-$ | $-$ |                                  |

**Explanatory notes:**
- LR = air pipe
- ÜR = overflow pipe
- AR = drainage line
- $f$ = cross-sectional area of tank filling pipe
- $F$ = cross-sectional area of main filling pipe

1. $\frac{1}{3} f$ only for tanks in which an overflow is prevented by structural arrangement
2. Determined in accordance with 1.4

### 2.3.2 The nominal diameter of sounding pipes, which pass through refrigerated holds at temperatures below 0 °C, shall be increased to an inside diameter of 50 mm.

### 2.3.3 The minimum wall thicknesses of sounding pipes are to be in accordance with Tables 13e.3 and Table 13e.4.

### 2.3.4 The pipe materials are to be selected according to Section 13d, C.2.

### L. Drinking Water Systems

National Regulations, where existing, are to be considered.

#### 1. Drinking water tanks

1.1 Drinking water tanks shall not have any walls in common with tanks containing substances other than feed water or distillate.

1.2 Pipes not carrying drinking water may not be led through drinking water tanks.

1.3 On units with ice class E1 and higher drinking water tanks located at the unit’s side above the ballast water line are to be provided with means for tank heating to prevent freezing.

#### 2. Drinking water tank connections

2.1 Filling connections shall be located sufficiently high above deck and shall be fitted with a closing device. Filling connections shall not be fitted to air pipes.

2.2 Air/overflow pipes shall be extended above the open deck. The upper openings of air pipes shall be fitted with automatic closing devices and shall be protected against the entry of insects.

2.3 Sounding pipes shall terminate sufficiently high above deck.

#### 3. Drinking water pipe lines

3.1 Drinking water pipe lines shall not be connected to pipe lines carrying other media.

3.2 Drinking water pipe lines are not to be laid through tanks which do not contain drinking water.

3.3 Drinking water supply to tanks which do not contain drinking water (e.g. expansion tanks of the fresh water cooling system) shall be made by means of an open funnel or with means of preventing flow-back.

### 4. Pressure water tanks/calorifiers

For design, equipment, installation and testing of pressure water tanks and calorifiers the requirements of Section 12c are to be observed.
Table 13e.3 Classification of minimum wall thickness group

<table>
<thead>
<tr>
<th>Piping system or position of open pipe outlets</th>
<th>Location</th>
<th>Drain lines and scupper pipes</th>
<th>Air, sounding and overflow pipes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanks with same media</td>
<td>Tanks with disparate media</td>
<td>below freeboard deck or bulkhead deck</td>
<td>above freeboard deck</td>
</tr>
<tr>
<td></td>
<td></td>
<td>without shut-off on unit’s side</td>
<td>with shut-off on unit’s side</td>
</tr>
<tr>
<td>Air, overflow and sounding pipes</td>
<td>C</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Scupper pipes from open deck</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Discharge and scupper pipes leading directly overhead</td>
<td>B</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Discharge pipes of pumps for sanitary systems</td>
<td></td>
<td></td>
<td>A</td>
</tr>
</tbody>
</table>

Table 13e.4 Minimum wall thickness of air, overflow, sounding and sanitary pipes

<table>
<thead>
<tr>
<th>Outside pipe diameter $d_a$ [mm]</th>
<th>Minimum wall thickness [mm]</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A 1</td>
<td>B 1</td>
<td>C 1</td>
<td></td>
</tr>
<tr>
<td>38 – 82,5</td>
<td>4,5</td>
<td>7,1</td>
<td>6,3</td>
<td></td>
</tr>
<tr>
<td>88,9</td>
<td>4,5</td>
<td>8</td>
<td>6,3</td>
<td></td>
</tr>
<tr>
<td>101,6 – 114,3</td>
<td>4,5</td>
<td>8</td>
<td>7,1</td>
<td></td>
</tr>
<tr>
<td>127 – 139,7</td>
<td>4,5</td>
<td>8,8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>152,4</td>
<td>4,5</td>
<td>10</td>
<td>8,8</td>
<td></td>
</tr>
<tr>
<td>159 – 177,8</td>
<td>5</td>
<td>10</td>
<td>8,8</td>
<td></td>
</tr>
<tr>
<td>193,7</td>
<td>5,4</td>
<td>12,5</td>
<td>8,8</td>
<td></td>
</tr>
<tr>
<td>219,1</td>
<td>5,9</td>
<td>12,5</td>
<td>8,8</td>
<td></td>
</tr>
<tr>
<td>244,5 – 457,2</td>
<td>6,3</td>
<td>12,5</td>
<td>8,8</td>
<td></td>
</tr>
</tbody>
</table>

1 wall thickness group, see Table 13e.3

5. Drinking water pumps

5.1 Separate drinking water pumps shall be provided for drinking water systems.

5.2 The pressure lines of the pumps of drinking water pressure tanks shall be fitted with screw-down non-return valves.

6. Drinking water generation

Where the distillate produced by the installation’s/unit’s own evaporator is used for the drinking water supply, the treatment of the distillate has to comply with the requirements of National Health Authorities.

M. Sanitary Systems

1. Sewage treatment

1.1 Units of 400 gross tonnage and above and units of less than 400 gross tonnage which are certi-
fied to carry more than 15 persons and with keel laying on or after 2003-09-27 are to be fitted with the following equipment:

- a sewage treatment plant approved according to Resolution MEPC.2(VI), or
- a sewage comminuting and disinfecting system (facilities for the temporary storage of sewage when the unit is less than 3 nautical miles from the nearest land, to be provided), or
- a holding tank

1.2 A pipeline for the discharge of sewage to a reception facility is to be arranged. The pipeline is to be provided with a standard discharge connection.

2. General arrangement

2.1 For ship-shaped units as well as decks, superstructures and deck houses on other units, which are not at a sufficient height above the water line, the requirements of the relevant "Rules of the 1966 Load-line Convention" are to be complied with.

Scuppers in sufficient numbers and sizes to provide effective drainage shall be fitted in all decks; hazardous and safe areas shall have separate drainage.

For scuppers and overboard discharges see also GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 1 – Hull Structures, Section 21, D.

2.2 Sanitary discharge pipes located in operational areas shall be specially protected. Individual sanitary discharge pipes shall be connected to common discharge pipes.

2.3 The minimum wall thicknesses of sanitary pipes below freeboard and bulkhead decks are specified in Table 13e.3 and 13e.4.

2.4 For discharge lines above freeboard deck/bulkhead deck the following pipes may be used:

- steel pipes according to Section 13d, Table 13d.4, group N
- pipes having smaller thickness when specially protected against corrosion, on special approval
- special types of pipes according to recognized standards, e.g. socket pipes, on special approval

2.5 For sanitary discharge lines below freeboard deck/bulkhead deck within a watertight compartment, which terminate in a sewage tank or in a sanitary treatment plant, pipes according to 2.4 may be used.

2.6 Penetrations of pipes of smaller thickness, pipes of special types and plastic pipes through bulkheads of type A are to be approved by GL.

2.7 If sanitary discharge pipes are led through cargo holds, they are to be protected against damage by cargo.

3. Sewage tanks and sewage treatment systems

3.1 Vent pipes shall be extended above the open deck and shall be fitted with automatic closing devices.

3.2 Sewage tanks are to be fitted with a filling connection, a rinsing connection and a level alarm.

3.3 The discharge lines of sewage tanks and sewage treatment tanks are to be fitted at the unit's side with screw-down non-return valves.

When the valve is not arranged directly at the unit's side, the thickness of the pipe is to be according to Table 13e.4, column B.

3.4 A second means of reverse-flow protection is to be fitted in the suction or delivery line of the sewage pump from sewage tanks or sewage treatment plants if, in the event of a 5° heel to port or starboard, the lowest internal opening of the discharge system is less than 200 mm above the lowest load line. 1

The second means of reverse-flow protection may be a pipe loop having an overflow height above the lowest load line of at least 200 mm at a 5° heel. The pipe loop is to be fitted with an automatic ventilation device located at 45° below the crest of the loop.

3.5 Where at a heeling of the unit of 5° at port or starboard, the lowest inside opening of the sewage system lies on the lowest load line or below, the discharge line of the sewage collecting tank is to be fitted in addition to the required reverse-flow protection device according to 3.4 with a gate valve directly at the shell plating. In this case the reverse-flow protection device needs not to be of screw-down type.

3.6 Ballast and bilge pumps may not be used for emptying sewage tanks.

4. Additional rules for units with requirements for damage stability

The sanitary arrangement and its discharge lines of units with special requirements for damage stability according to Chapter 1, Section 2, B.4, are to be so located that in the event of damage of one compartment no other compartment can be flooded.

If this condition cannot be fulfilled see GL Rules I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations, Section 11, T.3.

1 Where sanitary treatment arrangements are fitted with emergency drains to the bilge or with openings for chemicals, these will be considered as internal openings in the sense of these requirements.
N. Exhaust Gas Lines

1. Pipe layout
   1.1 Exhaust gas pipes from engines shall be installed separately from each other with regard to structural fire protection. The same applies to boiler exhaust gas pipes. Other designs are to be submitted for approval.
   
   1.2 Account is to be taken of thermal expansion when laying out and supporting the lines.
   
   1.3 Where exhaust gas lines discharge near water level, provisions are to be taken to prevent water from entering the engines.

2. Silencers
   
   2.1 Engine exhaust pipes shall be fitted with effective silencers or other suitable means are to be provided.
   
   2.2 Silencers shall be provided with an inspection opening.

3. Water drains
   Exhaust lines and silencers shall be provided with suitable drains of adequate size.

4. Insulation
   
   4.1 Exhaust gas lines, silencers and exhaust gas boilers shall be effectively insulated to prevent the ignition of combustible materials on their hot surfaces.
   
   4.2 Insulating materials have to be incombustible.
   
   4.3 Exhaust gas lines inside engine rooms shall be provided with metal sheathing or other approved type of hard sheathing.

5. Precautions against sparks from boiler and engine exhaust gases
   
   5.1 Funnels of steam boilers and other combustion chambers where spark emission could occur shall be fitted with suitable spark traps.
   
   5.2 Exhaust gases from the main and auxiliary engines shall be discharged to the atmosphere at a sufficient height.
   
   Exhaust lines shall be fitted with spark arrestors.
   
   5.3 Spark arrestors shall be provided with ample space for the deposit of soot particles and with readily accessible openings for cleaning, fitted with easily opened gastight covers and drains.
   
   5.4 For other technical design, construction and installation requirements not defined in this Section please refer to GL Rules 1 - Ship Technology, Part 1 - Seagoing Ships, Chapter 2 - Machinery Installations, Section 11.

O. Compressed Air Lines

1. General
   
   1.1 Pressure lines connected to air compressors are to be fitted with non-return valves at the compressor outlet.
   
   1.2 A water trap and an aftercooler have to be provided after the final stage of all compressors.
   
   1.3 Starting air lines may not be used as filling lines for air receivers.
   
   1.4 Only type-tested hose assemblies made of metallic materials may be used in starting air lines of diesel engines which are permanently kept under pressure.
   
   1.5 The starting air line to each engine is to be fitted with a non-return valve and a drain.
   
   1.6 Tyfons are to be connected to at least two compressed air receivers.
   
   1.7 A safety valve is to be fitted behind each pressure-reducing valve.
   
   1.8 Pressure water tanks and other tanks connected to the compressed air system are to be considered as pressure vessels and shall comply with the requirements in Section 12c for the working pressure of the compressed air system.
   
   1.9 For compressed air connections for blowing through sea chests refer to F.1.5.
   
   1.10 The provisions for compressed air supply to pneumatically operated valves and quick-closing valves have to be agreed with GL.
   
   1.11 Requirements for starting engines with compressed air, see Section 3, H.2.

2. Control air systems
   
   2.1 Control air systems for essential consumers are to be provided with the necessary means of air treatment.
   
   2.2 Pressure reducing valves in the control air system of main engines are to be redundant.
Section 13f

Drilling and Production Piping Systems

A. General

The design and construction of piping systems for drilling and production on offshore units or installations require the full application of internationally accepted petroleum industry standards and specifications (e.g. API/ANSI). The maximum design pressure within the frame of these specifications is 20000 psi (1400 bar) and the temperature range is – 30 °C to 350 °C (– 20 °F to 650 °F). For applications outside of these pressure and temperature ratings special considerations have to be given to specific material properties which require the approval by GL. Reference shall be made also to Section 11, C.

B. Pressure Rating

1. Offshore process systems shall be classified into systems of standardized pressure rating which should be linked to the ratings of specifications for flanges, valves, fittings and other equipment.

2. Since the API specification starts with 2000 psi (140 bar), all systems operating at pressures higher than 2000 psi shall be in compliance with API specifications. Medium or low pressure systems shall comply to ANSI standards which require strict observance of operating temperatures (derating).

3. The following pressure rating classification is recommended for piping systems:

- wellhead pressure 140 to 1400 bar (API 2000 to 20000 psi), flowlines and manifolds between wellhead and first stage pressure control
- high pressure 70 to 140 bar (API 2000 or ANSI 1500 psi), piping for separation and treatment (1. stage)
- medium pressure 35 to 70 bar (ANSI 300 psi), piping for separation, pipeline entries
- low pressure 16 to 20 bar (ANSI 150 psi), piping for process, loading lines and auxiliary petroleum equipment

C. Special Considerations for the Design of Drilling and Production Piping Systems

1. General considerations

1.1 Special attention has to be drawn to the following points when considering these service Classifications.

1.2 Drilling and/or workover rigs mounted on fixed installations or floating units are in general mobile units which should in principle be designed for multiple hydrocarbon services. It is recommended to select equipment and piping systems for the most severe service. At least permanent installations which may be difficult and costly to exchange shall be designed and constructed to meet the most severe service conditions, e.g. blow-out preventer lines, kill and choke lines, manifolds, etc.

1.3 Production facilities and/or processing facilities on installations/units shall be designed to meet requirements for corrosive service, since produced reservoir water contains generally chloridic salts and CO₂ gas, highly corrosive agents. The use of large volumes of acids for reservoir treatments and the return of the spent acids affects all metal surfaces in contact. Hydrogen sulfide, originally not present in reservoir fluids or gases, may be developing during the service life of an oil field due to growth of bacteria activities. Sour service conditions should be considered at least for critical high pressure systems, e.g. choke and flow lines, separators designed for well pressure or high pressure service.

The design of above piping systems requires the observance of the different service conditions as follows.

2. Non-corrosive hydrocarbon service

Seamless pipes are generally preferred due to its consistent quality. If welded pipes for large diameter piping are chosen, electric resistance welded and submerged arc welded grades may be selected for medium strength steels. However, special welding procedures and close supervision are necessary if higher strength steels are used.

The following grades are specifically excluded from hydrocarbon service:

2.1 All grades of ASTM A 120

2.2 Furnace lap weld and furnace butt weld

2.3 Fusion weld per ASTM A 134 and A 139

2.4 Spiral weld, if not specially accepted by GL.
3. Corrosive hydrocarbon service

Quality recommendations and limitations are the same as above, yet the following corrosion protection practices have to be considered:

- Means for continuous inhibition of corrosive media or application by batch treatments and/or control of pH-value.
- Use of corrosion resistant alloys. Special care has to be taken that formation of electrochemical elements is prevented. High-chloride content in produced fluids, the use of hydrochloric acid (even occasional), or return of spent acid may not permit the application of certain alloys (chloride stress cracking).
- Application of corrosion resistant overlays or cladding.
- Application of resistant coatings. Gas bearing fluids, pressure changes or high temperatures may limit the application.
- Insertion of corrosion resistant hoses in straight lines for corrosion protection and prevention of asphaltene or paraffin deposits.
- Adequate provision shall be made for control of chemical treatments and corrosion monitoring (coupons, electrical probes, ND-testing).

4. Sulphide stress cracking service

4.1 Only seamless pipes shall be used in pressurized piping systems.

4.2 Cold expanded pipes shall not be used if not normalized, quenched and tempered under controlled methods accepted by GL.

4.3 Only materials accepted by NACE MR 01-75 or by special agreement by GL shall be used. Detailed conditions for sour service are explained in Section 15.

D. Flange Connections for Piping, Valves and Fittings in Hydrocarbon Services

Flange connections for piping, valves, fittings or other equipment in hydrocarbon piping systems shall be designed, constructed and tested for maximum working pressures and temperatures as classified by the internationally accepted petroleum industry standards and specification.

1. Comparable pressure ratings API/ANSI

1.1 According to API specifications the comparison Table 13f.1 is applicable, yet material properties and temperature limitations as laid down by API have to be observed:

- Allowable temperature range, without derating:
  - 30 °C to + 120 °C
  (-20 °F to +250 °F)
- Required material properties:
  | Tensile strength [psi] | 90000 | 70000 |
  | Yield strength [psi]   | 60000 | 45000 |

Note

For reasons of good oil field practice it is strongly recommended to use for the construction of offshore facilities only materials for flanges, valves and fittings, which have the required properties as laid down by API for both API and ANSI flanges, in order to prevent mix-ups in warehouses or during construction.

Table 13f.1 Comparison API/ANSI

<table>
<thead>
<tr>
<th>Maximum allowable working pressure [bar g]</th>
<th>Maximum allowable working pressure [psi g]</th>
<th>API class</th>
<th>ANSI class</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>300</td>
<td>–</td>
<td>150</td>
</tr>
<tr>
<td>50</td>
<td>700</td>
<td>–</td>
<td>300</td>
</tr>
<tr>
<td>70</td>
<td>1000</td>
<td>–</td>
<td>400</td>
</tr>
<tr>
<td>140</td>
<td>2000</td>
<td>2000</td>
<td>600</td>
</tr>
<tr>
<td>210</td>
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</tr>
<tr>
<td>350</td>
<td>5000</td>
<td>5000</td>
<td>1500</td>
</tr>
<tr>
<td>420</td>
<td>6000</td>
<td>–</td>
<td>2500</td>
</tr>
<tr>
<td>700</td>
<td>10000</td>
<td>10000</td>
<td>–</td>
</tr>
<tr>
<td>1000</td>
<td>15000</td>
<td>15000</td>
<td>–</td>
</tr>
<tr>
<td>1400</td>
<td>20000</td>
<td>20000</td>
<td>–</td>
</tr>
</tbody>
</table>

1.2 According to ANSI standard, the comparison Table 13f.2 may be used based on ANSI material specification and medium range temperatures (for hydrocarbon services):

- Medium range temperatures:
  - 30 °C to + 120 °C
  (-20 °F to +250 °F)
- ANSI requirement for material properties:
  | Tensile strength [psi] | 60000 | 70000 |
  | Yield strength [psi]   | 30000 | 36000 |
### Table 13f.2 Comparison ANSI/API

<table>
<thead>
<tr>
<th>Maximum allowable working pressure [bar g]</th>
<th>Maximum allowable working pressure [psi g]</th>
<th>ANSI class</th>
<th>API class</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>225</td>
<td>150</td>
<td>–</td>
</tr>
<tr>
<td>48</td>
<td>690</td>
<td>300</td>
<td>–</td>
</tr>
<tr>
<td>64</td>
<td>920</td>
<td>400</td>
<td>2000</td>
</tr>
<tr>
<td>100</td>
<td>1380</td>
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<td>3000</td>
</tr>
<tr>
<td>140</td>
<td>2100</td>
<td>900</td>
<td>5000</td>
</tr>
<tr>
<td>250</td>
<td>3500</td>
<td>1500</td>
<td>5000</td>
</tr>
<tr>
<td>400</td>
<td>5700</td>
<td>2500</td>
<td>–</td>
</tr>
</tbody>
</table>

### Note

Compared to 1.1, API equipment series 2000 to 5000 (valves, etc.) is oversized compared to ANSI max. pressure rating.

Temperature limitations (reduction of maximum working pressures) have to be considered for temperatures exceeding 120 °C or 250 °F.

2. Welding neck connections shall be used generally in hydrocarbon services for all connections of 2" and larger diameters. Threaded connections in such sizes shall be limited for use on wellhead decks or other applications, to be individually approved by GL.

3. Flange connections for piping, fittings or other equipment designed with internal, tapered threaded end or outlet connections (API) shall be limited to the following ratings and sizes:

   - 3000 psi – 2" (exceptionally up to 6")
   - 5000 psi – 3/4" (exceptionally up to 2")
   - 10000 psi – 1/2" (no exception)

   These limitations are not applicable to tubings, casings and hangers.

4. Ring type joint flanges (RTJ) shall be preferably used above 70 bar (1000 psi), but in any case above 140 bar (2000 psi) maximum allowable operating pressure, with the following provisions:

   - Raised face joint flanges (RFJ) with flat gaskets may be used below 70 bar (1000 psi).
   - Ring joint gaskets may be of oval or octagonal type.
   - For pressures higher than 700 bar (10000 psi) raised face flanges of 6 BX-type in accordance with API Specification 6 A have to be used equipped with pressure energized octagonal ring joint gaskets.
   - For flange connections, where the occurrence of bending moments or vibrations cannot be prevented, the application of raised face flanges and pressure energized ring joint gaskets is recommended in order to prevent asymmetric mechanical stresses.
   - The design and construction of ring joint type flanges and gaskets has to meet the requirements of API Specification 6 A.
Section 14

Flares and Cold Vents

A. General

1. Scope

The following requirements apply to flares and cold vents on mobile offshore units and fixed offshore installations, used for the safe disposal of hydrocarbon gases and vapours and other gases associated with drilling, production and processing of mineral oil and gas. Special requirements for sour gas have to be considered according to Section 17, C.

2. Reference to other rules, regulations and standards

Designs based on other internationally acknowledged rules, regulations or standards will be accepted if they provide an equal degree of safety.

Attention is drawn also to governmental regulations and/or requirements imposed by local authorities.

3. Orientation, arrangement

3.1 The target of a safe dilution of the released gas shall be duly considered. For the orientation of the flare or cold vent relative to the offshore installation(s)/unit, careful consideration shall be given to prevailing wind directions and speeds.

3.2 In general the flare or cold vent shall be positioned downwind of any production/process areas and accommodation modules.

3.3 The arrangement of the flare or cold vent shall be determined with due regard to unimpeded:

- helicopter and boat traffic
- crane boom circles
- access to boat landings from the water side (marine craft) and from the installation's/unit’s escape routes

3.4 Accessibility for maintenance of the flare or vent tip has to be ensured.

4. Noise

Noise produced by flares and cold vents shall at all normally manned locations be within such limits as to ensure that:

- communication by portable radio or telephone is still possible
- public address announcements and acoustic warning signals are audible throughout the installation(s)/unit.

This applies in particular to maximum flow conditions.

5. Design

5.1 For safety and environmental reasons the need for flaring shall be minimized.

5.2 In the design of the flare/cold vent system provisions shall be made to avoid:

- blowback of the flame
- accumulation of liquids in the flare piping
- carry-over of liquids, e.g. by appropriately sized knock-out drum
- precipitation of unburnt liquid droplets onto equipment or structure, e.g. by appropriately sized droplet removal systems
- hydrocarbon contamination of air intakes for heating, ventilation, air condition (HVAC) and combustion air
- excessive internal back pressure resulting from critical discharge scenarios
- excessive forces due to surge effects on the piping
- thermal stresses caused by temperature differences between discharged gas and components of the system
- fallout/generation of sludge

5.3 The safety arrangements for the flare/cold vent systems shall be incorporated into the installation’s/unit’s Emergency Shut Down (ESD) system, as necessary.

5.4 The hydraulic and thermal capacity of a flare/cold vent shall be determined on a well defined worst case scenario, taking into account the highest possible flow rates, e.g. in a blowdown situation, and considering worst case gas composition.
5.5 Selection of materials shall be made with due regard to corrosion and erosion attack.

B. Flares

1. Special requirements

A flare system shall be properly designed with due regard to:

- complete combustion (smokeless operation to be ensured by manufacturer)
- flame retention and stability even under surging gas conditions and maximum wind conditions

2. Documents for approval

Documentation on the following shall be submitted for review/approval:

- description of the flare type, materials and manufacturer, type of seal
- description of operating and safety philosophy with regard to flaring
- process flow sheet
- piping and instrumentation diagrams (PIDs) including safety facilities, flare collecting headers and flare utilities
- design of vessels, e.g. scrubbers, knock-out drums
- radiation calculations (flare study) for hot flares respectively dispersion study for cold vents
- plans for thermal shielding, insulation and protection of structure and pressurized equipment, as far as necessary
- plans of provision and location of heat shields for personnel escape routes, as far as necessary

3. Thermal radiation levels

The intensity and distribution of thermal radiation shall be calculated by using an appropriate method in order to cover the entire operating range of the flare.

In most cases, structural components and equipment can safely tolerate higher degrees of heat density than those defined for personnel in Table 14.1. However, if any items vulnerable to overheating problems are involved, such as construction materials that have low melting points (for example, aluminium or plastic), heat-sensitive streams, flammable vapour spaces, or electrical equipment, then the effect of radiant heat on them may need to be evaluated. Thus, special attention may be required for helicopter decks made of aluminium. Structural integrity and operability have to be maintained, e.g. by thermal insulation.

Further consideration shall be given to the thermal stability of lubricants, e.g. for drilling equipment, and to the limitation of surface temperatures in hazardous areas.

4. Pilot burner and ignition system

A pilot burner shall be provided in such an arrangement to ensure a stable pilot flame under all environmental conditions. Means to verify the existence of the pilot flame and to verify that the pilot burner does ignite the gas flow instantaneous on discharge are required, e.g. installation of flame monitors.

In order to start and maintain a flame, an ignition system shall be provided capable of remote operation, so that neither personnel nor ignite controls can be affected by detrimental heat radiation.

5. Safety arrangements

5.1 Provision shall be made to prevent the ingress of air into the flare system and possible formation of explosive atmosphere at low flow rates. This may be achieved by providing a continuous purge gas system or equivalent.

5.2 Suitably arranged alarms for reception at a manned control station shall be provided for the flare system, e.g.:

- pilot flame out
- low pressures in the gas line or pilot gas line
- levels in scrubbers/knock-out drums

Pilot flame monitors are to be located such that heat radiation from the flare does not render them inoperable.

5.3 Where drain pumps for scrubbers/knock-out drums are provided, their operation shall be automatic.

C. Cold Vents

1. Special requirements

The approval of cold vents follows, to the applicable extent, the same procedure as for flares.
A cold vent system shall be properly designed with due regard to dispersion to ensure that neither explosive nor toxic gas mixtures may be created in the installation/unit under the given environmental conditions.

2. **Accidental ignition**

A snuffing system or equivalent shall be provided to immediately extinguish the flame in case of accidental ignition of the gases.

For such cases protective measures for personnel and equipment may be required, depending upon their distance from the flame.

---

### Table 14.1 Recommended total design radiation

<table>
<thead>
<tr>
<th>Permissible design level (K)</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>British Thermal Units/hour/foot²</strong></td>
<td><strong>Kilowatt/m²</strong></td>
</tr>
<tr>
<td>5000</td>
<td>15,77</td>
</tr>
<tr>
<td>3000</td>
<td>9,46</td>
</tr>
<tr>
<td>2000</td>
<td>6,31</td>
</tr>
<tr>
<td>1000</td>
<td>4,73</td>
</tr>
<tr>
<td>500</td>
<td>1,58</td>
</tr>
</tbody>
</table>

**Remarks:**

1. On towers or other elevated structures where rapid escape is not possible, ladders shall be provided on the side away from the flare, so the structure can provide some shielding when K is grater than 2000 BTU/hour/ft² (6,31 kW/m²)

2. Solar radiation contribution varies by geographical location and is generally in the range of 250 to 330 BTU/hour/ft² (0,79 to 1,04 kW/m²)
Section 15

Special Requirements for Materials in \( \text{H}_2\text{S} \)-containing Environments in Oil and Gas Production

A. General

1. Scope

This Section covers special requirements for the selection and qualification of materials, welding and corrosion protection of metallic equipment used in oil and gas production and in natural gas sweetening plants in \( \text{H}_2\text{S} \) – containing environments, where the failure of such equipment could pose a risk to the health and safety of the public and personnel or to the environment. These requirements are in addition to the basic and welding requirements defined in other Sections of this Chapter.

2. Terms and definitions

2.1 Equipment in \( \text{H}_2\text{S} \) – containing environments

Metallic equipment included in this Sections and used in oil and gas production are e.g. for drilling well construction and well servicing equipment, for wells subsurface equipment, gas lift equipment, wellheads and christmas trees und for transport and production gathering lines, field facilities and field processing plants, sour-water handling equipment, natural gas treatment plants, transportation pipelines for liquids, gases and multiphase fluids.

2.2 Mechanisms of cracking that can be caused by \( \text{H}_2\text{S} \)

Sulfide Stress Cracking SSC

This means cracking of metal involving corrosion and tensile stress (residual and/or applied) in the presence of water and \( \text{H}_2\text{S} \). SSC is a form of hydrogen stress cracking (HSC) and involves embrittlement of the metal by atomic hydrogen that is produced by acid corrosion on the metal surface. Hydrogen uptake is promoted in the presence of sulfides. The atomic hydrogen can diffuse into the metal, reduce ductility and increase susceptibility to cracking. High strength metallic materials and hard weld zones are prone to SSC.

Stress Corrosion Cracking SCC

This means cracking of metal involving anodic processes of localized corrosion and tensile stress (residual and/or applied) in the presence of water and \( \text{H}_2\text{S} \). Chlorides and/or oxidants and elevated temperature can increase the susceptibility of metals to this mechanism of attack.

Hydrogen – Induced Cracking HIC

Planar cracking that occurs in carbon and low alloy steels when atomic hydrogen diffuses into the steel and then combines to form molecular hydrogen at trap sites. Cracking results from the pressurization of trap sites by hydrogen. No externally applied stress is needed for the formation of hydrogen-induced cracks. Trap sites capable of causing HIC are commonly found in steels with high impurity levels that have a high density of planar inclusions and/or regions of anomalous microstructure (e.g. banding) produced by segregation of impurity and alloying elements in the steel. This form of hydrogen-induced cracking is not related to welding.

Stepwise Cracking SWC

Means cracking that connects hydrogen-induced cracks on adjacent planes in steel. This term describes the crack appearance. The linking of hydrogen – induced cracks to produce stepwise cracking is dependent upon local strain between the cracks and embrittlement of the surrounding steel by dissolved hydrogen. HIC/SWC is usually associated with low – strength plate steels used in the production of pipes and vessels.

Stress – Oriented Hydrogen – Induced Cracking SOHIC

Staggered small cracks formed approximately perpendicular to the principal stress (residual or applied) resulting in a “ladder – like” crack array linking (sometimes small) pre – existing HIC cracks. The mode of cracking can be categorized as SSC caused by a combination of external stress and the local strain around hydrogen – induced cracks. SOHIC is related to SSC and HIC/SWC. It has been observed in parent material of longitudinally welded pipe and in the heat – affected zone (HAZ) of welds in...
pressure vessels. SOHIC is a relatively uncommon phenomenon usually associated with low-strength ferritic pipe and pressure vessel steel.

**Soft Zone Cracking (SZC)**

Form of SSC that may occur when steel contains a local “soft zone” of low yield strength material.

Under service loads, soft zones may yield and accumulate plastic strain locally, increasing the SSC susceptibility to cracking of an otherwise SSC-resistant material. Such soft zones are typically associated with welds in carbon steels.

**Hydrogen Stress Cracking (HSC)**

Cracking that results from the presence of hydrogen in a metal and tensile stress (residual and/or applied).

HSC describes cracking in metals that are not sensitive to SSC but which may be embrittled by hydrogen when galvanically coupled, as the cathode, to another metal that is corroding actively as an anode. The term galvanically induced HSC has been used for this mechanism of cracking.

**Galvanically – induced Hydrogen Stress – Cracking (GHSC)**

Cracking that results due to the presence of hydrogen in a metal, induced in the cathode of a galvanic couple, and tensile stress (residual and/or applied).

### 2.3 H₂S - Cracking related Terms

**Partial Pressure**

Means pressure that would be exerted by a single component of a gas if present alone, at the same temperature, in the total volume occupied by the mixture.

For a mixture of ideal gases, the partial pressure of each component is equal to the total pressure multiplied by its mole fraction in the mixture, where its mole fraction is equal to the volume fraction of the component.

**Sour Service**

Exposure to oilfield environments that contain H₂S and can cause cracking of materials by the mechanisms defined in 2.2.

### 2.4 Material related terms

**Austenite**

Face-centred cubic crystalline phase of iron-based alloys.

**Austenitic stainless steel**

Stainless steel whose microstructure, at room temperature, consists predominantly of austenite.

**Ferrit**

Body-centred cubic crystalline phase of iron-based alloys.

**Ferritic steel**

Steel whose microstructure at room temperature consists predominantly of ferrite.

**Ferritic stainless steel**

Stainless steel whose microstructure, at room temperature, consists predominantly of ferrite.

**Duplex stainless steel**

Austenitic/ferritic stainless steel

Stainless steel whose microstructure at room temperature consists primarily of a mixture of austenite and ferrite.

**Martensite**

Hard, supersaturated solid solution of carbon in iron characterized by an acicular (needle-like) microstructure.

**Martensitic steel**

Steel in which a microstructure of martensite can be attained by quenching at a cooling rate fast enough to avoid the formation of other microstructures.

**Corrosion – Resistant Alloy (CRA)**

Alloy intended to be resistant to general and localized corrosion of oilfield environments that are corrosive to carbon steels.

**Pitting Resistance Equivalent Number (PREN)**

Number, developed to reflect and predict the pitting resistance of a CRA, based upon the proportions of Cr, Mo, W and N in the chemical composition of the alloy.

### 2.5 Welding related terms

**Heat – Affected Zone (HAZ)**

That portion of the base metal that is not melted during brazing, cutting or welding, but whose microstructure and properties are altered by the heat of these processes.

**Welding Procedure Specification (WPS)**

**Procedure Qualification Record (PQR)**
B. Material Selection

1. General

1.1 Approval by GL

All materials listed in or qualified in accordance with ISO 15156-1 to 3 for all or some mechanisms of cracking caused by H₂S and used for equipment in oil and gas production shall be approved by GL under consideration of the material properties, the equipment type, the service conditions known to affect the susceptibility of metallic materials to cracking in H₂S service and the metallurgical changes that occur on welding. The WPSs and PQRs shall be provided including hardness testing in accordance with ISO 15156-2.

The materials listed in ISO 15156-1 to 3 or qualified by this Standard are resistant to cracking in defined H₂S–containing environments in oil and gas production but not necessarily immune to cracking under all service conditions and immune to corrosion.

1.2 Evaluation and definition of service conditions

Before selecting or qualifying materials using ISO 15156-2 and -3, the user of the equipment shall define, evaluate and document the service condition to which materials may be exposed for each application. The defined condition shall include both intended exposures and unintended exposures which may result from the failure of primary containment or protection methods. Particular attention shall be paid to the quantification of those factors known to affect the susceptibility of materials to cracking caused by H₂S:

- H₂S partial pressure or equivalent dissolved concentration in the water phase
- acidity (in situ pH) of the water phase
- the concentration of dissolved chloride or other halide
- the presence of oxygen, elemental sulfur or other oxidant
- exposure to non-production fluids
- exposure temperature
- galvanic effects
- total tensile stress (applied plus residual)
- time of exposure

The documented service conditions shall be used for one or more of the following purposes:

a) to provide the basis for selection of pre – qualified SSC/SCC resistant materials (see Annex A of ISO 15156-2 and -3)

b) to provide the basis for qualification and selection based upon documented field experience (see ISO 15156-1/8.2)

c) to define the laboratory test requirements to qualify a material for H₂S service with respect to one or more of SSC, SCC, HIC, SOHIC, SZC and/or GHSC (see ISO 15156-1/8.3 and Annex B of ISO 15156-2 and -3)

d) to provide the basis for the reassessment of the suitability of existing alloys of construction, using, b) and/or c) in the event of changes to the actual or intended service conditions.

1.3 Material description and documentation

The material to be qualified shall be described and documented, such that those of its properties likely to affect performance in H₂S–containing media are defined. The tolerances or ranges of properties that can occur within the material shall be described and documented.

Metallurgical properties known to affect performance in H₂S–containing environments include:

- chemical composition
- method of manufacture
- product form
- strength
- hardness
- amount of cold work
- heat – treatment condition
- microstructure

2. Carbon Steels, Cast Irons and Low Alloy Steels

2.1 Influence of Partial Pressure of H₂S

Normally, no precautions are required for the selection of steels for use at a partial pressure of H₂S <0.3 kPa (0.05 psi). Nevertheless a number of factors that can affect a steel’s performance in this region should be considered, as follows:

- Steels that are highly susceptible to SSC and HSC may crack.
- A steel’s physical and metallurgical properties affect its inherent resistance to SSC and HSC.
- Very high strength steels can suffer HSC in aqueous environments without H₂S. Above about 965 MPa (140 ksi) yield strength, attention may be required to steel composition and processing to ensure that these steels do not exhibit SSC or HSC.
- Stress concentrations increase the risk of cracking.

If the partial pressure of H₂S in the gas is equal to or greater than 0.3 kPa (0.05 psi), SSC – resistant steels
shall be selected using Annex A.2 of ISO 15156-2. The user should consider SOHIC and SZC, when evaluating carbon steels in plate form and their welded products for sour service in H₂S-containing environments. They have caused sudden failures in parent steels (SOHIC) and in the HAZ of welds (SOHIC and SZC). Their occurrence is thought to be restricted to carbon steels. The presence of sulfur or oxygen in the service environment is thought to increase the probability of damage by these mechanisms.

The user shall consider HIC/SWC when evaluating flat rolled carbon steel products for sour service environments containing even trace amounts of H₂S. The probability of HIC/SWC is influenced by steel chemistry and manufacturing route. The level of sulfur in the steel is of particular importance, typical maximum acceptable levels for flat rolled are 0.003% and seamless products 0.01%. Conventional forgings with sulfur levels less than 0.025%, and castings, are not normally considered sensitive to HIC or SOHIC. Annex B of ISO 15156-2 provides guidance on test methods and acceptance criteria to evaluate resistance to SSC, SOHIC, SZC, HIC and SWC.

2.2 Influence of acidity (in situ pH) of the water phase

The severity of the H₂S – containing environment is higher at low pH. Clause 7.2 of ISO 15156-2 provides four regions of severity depending on H₂S partial pressure and in situ pH. In the absence of suitable choices from Annex A, carbon and low alloy steels may be tested and qualified for use under specific sour service conditions or for use throughout a given SSC Region.

2.3 Influence of Hardness

The hardness of parent materials and of welds and their HAZ play an important role in determining the SSC resistance of carbon and low alloy steels. Hardness control can be an acceptance means of obtaining SSC resistance.

The metallurgical changes that occur when welding carbon and low alloy steels can affect their susceptibility to SSC, SOHIC and SZC. WPSs and PQRs shall include hardness testing in accordance to ISO 15156-2.

2.4 Requirements for carbon and low alloy steels

General carbon and low alloy steels shall comply with ISO 15156-2 Annex A.2.1.2 through A.2.1.9.

For applications of product forms and equipments Annex A.2.2 through A.2.4 shall be used und considered for other steels grades.

3. Cracking – resistant CRAs and other alloys

3.1 General

The material groups of cracking – resistant CRAs and other alloys in

ISO 15156 – 3 Annex A and D are as follows :

− Austenitic stainless steels (see A.2, A.3 and Table D.1 and D.2)

− Ferritic stainless steels (see A.5 and Table D.5)

− Martensitic stainless steels (see A.6 and Table D.6)

− Duplex stainless steels – austenitic/ferritic (see A.7 and Table D.7)

− Precipitation – hardened stainless steels (see A.8 and Table D.8)

− Nickel – based alloys (see A.4, A.9 and Table D.4 and D.9)

− Cobalt – based alloys (see A.10 and Table D.10)

− Titanium and Tanralum (see A.11 and Table D.11)

− Copper- and aluminium – based alloys (see A.12)

CRAs and other alloys shall be selected for their resistance to SSC, SCC and/or GHSC as required by the intended service.

In defining the severity of H₂S – containing environments, exposures that might occur during system upsets or shutdowns, etc. shall also be considered. Such exposures can include unbuffered, low pH, condensed water and acids used for well stimulation. In the case of stimulation acids, conditions occurring during backflow shall be considered.

Additional to 1.2, factors affecting the cracking resistance, for CRAs the pitting resistance PREN shall be considered.

3.2 Environmental Limits

The environmental limits given in ISO 15156 – 3, Annex A for the material groups for H₂S partial pressure, pH, temperature, chloride concentration and elemental sulfur shall be considered. These limits apply collectively. The pH used in the tables of Annex A corresponds to the minimum in situ pH. In preparing the material selection tables it is assumed that no oxygen is present in the service environment.

3.3 Influence of Welding

The hardness of parent materials and of welds and their HAZ play an important role in determining the SSC, SCC and GHSC resistance of CRAs and other alloys. Hardness control can be an acceptance means of obtaining SSC, SCC and GHSC resistance.
The metallurgical changes that occur when welding CRAs and other alloys can affect their susceptibility to SSC, SCC and/or GHSC.

Welding PQRs shall include documented evidence demonstrating satisfactory cracking resistance under conditions at least as severe as those of the proposed application. Such evidence shall be based upon one or more of the procedures provided in A.1.2. The requirements and recommendations given in ISO 15156-3 Annex A may not be appropriate for all combinations of parent and weld metals used in the fabrication of equipment and components. The equipment may require evidence of successful cracking resistance testing, as part of the welding procedure qualification, to ensure the welding produced adequate resistance to SSC, SCC and GHSC for the application. PQRs shall include hardness testing in accordance to ISO 15156-2 Chapter 7.3.3. Weld hardness and the hardness of parent materials shall be as specified in ISO 15156-3 Annex A.

3.4 PREN

There are several variations of the PREN. All were developed to reflect and predict the pitting resistance (and crevice resistance) of Fe/Ni/Cr/Mo CRAs in the presence of dissolved chlorides and oxygen, e.g. in sea water. Though useful, these indices are not directly indicative of corrosion resistance in H₂S-containing oil field environments.

The PREN shall be calculated as follows:

\[
\text{PREN} = \%\text{Cr} + 3.3 (\%\text{Mo} + 0.5\%\text{W}) + 16\%\text{N}
\]

Where the mass fraction in the alloy, is expressed as a percentage of the total composition. Higher values of PREN reflect pitting and crevice resistance at higher temperatures (see DIN 81249 – 1997 and Paper No. 01004 – 2001 by NACE International: H₂S Resistant Materials for Oil & Gas Production).

3.5 Requirements for CRAs and other alloys

General CRAs and other alloys shall comply with ISO 15156-3 Annex A. For applications of product forms and equipments Annex A shall be used und considered for other alloys not included in Annex A.
Section 16

Control System, Instrumentation

A. General

1. Scope

This Section applies to control systems and instrumentation on mobile units and fixed offshore installations as defined in Chapter 1, Section 1, B. Reference is made also to Sections 11, 13a – 13e and to Chapter 6.

2. Reference to other rules, regulations and standards

Apart from these Rules other internationally accepted rules, regulations and standards will be considered if they provide an equal degree of safety.

Attention is drawn also to governmental regulations and/or requirements imposed by local Authorities.

B. Control Systems

1. Definitions

The term control systems, for the purpose of these Rules, is meant to cover open loop as well as closed loop control circuits, from the control signal input through the control circuit and up to and including the final control element.

2. Documents for review and approval

2.1 The following documents are to be submitted to GL for approval, if applicable:

− functional design specifications
− software design specification
− software documentation (special agreement between system designer and GL)
− piping and instrumentation diagrams (P&ID)
− cause and effect charts
− loop diagrams
− process operation systems, incl. those for remote operation on other units or installations, where applicable
− earthing layout
− process shutdown system
− fire and gas detection system (see also Chapter 6, Section 9, C.)
− fire extinguishing system (see also Section 10)

2.2 Where modifications of the original design that may affect its safety concept become necessary during the construction phase or thereafter, revised drawings have to be submitted to GL for approval. After completion of the installation, "as built" drawings are explicitly required to be submitted.

2.3 For components of the control system to be installed in hazardous areas adequate documentation verifying their suitability is required, as far as applicable, e.g. type approval Certificates of a recognized institution.

3. Design

3.1 Fail-safe principle

Automatic control systems (not single components only) shall be designed to the fail-safe principle; i.e. a system, upon loss of control energy, shall remain in the operating condition at the time of failure, or attain a safe or least hazardous condition with regard to

− personnel protection
− environmental protection
− process safety.

3.2 Loss of energy

Upon loss of control energy a visual and audible alarm shall be actuated at a central control position.

Where failure of control energy cannot be tolerated, e.g., for safety systems, a back up supply, e.g. UPS, shall be provided which is activated automatically upon failure of the main supply.

3.3 Autonomy of alarm systems

Alarm and safety systems shall, to the greatest extent practicable, be independent of control systems. This applies to the whole system, from the signal input through the final control element.

3.4 Testing

At least for vital safety systems like the Emergency Shutdown System (ESD), means shall be provided for the testing of the complete circuit (from sensor up to final control element) without interfering with the ongoing production process.
3.5 Manual overriding
Means shall be provided for the manual overriding of automatic control/safety systems. Such means shall be safeguarded against unauthorized use.

C. Instrumentation

1. Definitions
The term instrumentation, for the purpose of these Rules, is meant to cover all the mechanical, electrical and electronic control and monitoring instruments used in the operation of safety systems and in open and closed loop control systems. It includes also the pertinent piping and cables.

2. Documents for review and approval

2.1 Documentation on instrumentation shall be submitted as required by GL. This applies in general to novel types of design, or where instruments are to be employed in systems vital to the safety of the installation/unit or parts thereof. Examples would be pressure safety valves (materials, capacity, set pressure) or complex instruments for which a detailed explanation is required.

2.2 For instruments to be used in hazardous areas, documents verifying their suitability are required, as applicable, e.g. type approval Certificates of a recognized Institution.

3. Design

3.1 General

3.1.1 Instruments, cables and piping shall be so fitted that protection from the salty and/or H₂S laden atmosphere, frost and heat, dust, vibrations and mechanical damage is ensured. Adequate ventilation may be required for heat-sensitive instruments in vital systems.

3.1.2 Instruments, filters, etc. shall be fitted to provide easy access for maintenance. Means shall be provided for the periodical calibration (test connections, easy removability), as applicable.

3.1.3 Selection of materials shall be such as to avoid corrosion (Examples: stainless steel piping/carbon steel clamps. Stainless steel or aluminium nameplates/carbon steel rivets or wire).

3.2 Instruments

3.2.1 Instruments with analogue or digital dials shall be so fitted that accessibility and legibility are ensured.

3.2.2 Each instrument fitted in a hazardous area shall bear permanent identification therefore.

3.2.3 The labelling of instruments as installed shall be in strict accordance with designations in drawings. This is stressed particularly for safety systems.

3.2.4 For instruments in safety systems, type approved instruments shall preferably be used. Reference is made to the GL homepage www.gl-group.com.

3.2.5 Instrumentation in control rooms shall be arranged in accordance with ergonomic principles. Panels shall be divided into sections according to the process areas. Mimic diagrams or visualisations on monitors shall be fitted to enhance the safety of operation.

3.2.6 Provision shall be made for the loop testing of circuits and systems after installation.

3.3 Cabling

3.3.1 Cable types used between hazardous and non-hazardous areas shall be impervious to gas and liquids.

3.3.2 Cables for intrinsically safe circuits shall be easily identifiable. Cables with light blue sheath shall preferably be used.

3.3.3 Where so-called conduit systems are used for instrumentation wiring, the adequate filling of the fittings with appropriate sealing compound shall be ensured.

3.4 Valves and pipes

3.4.1 Separation of control loops from process media shall be ensured.

3.4.2 Pressure gauges shall be of the appropriate precision class.

3.4.3 Pressure safety valves (PSV) shall be dimensioned for the "worst case" situation, see Section 13c.

3.4.4 Where dual PSV arrangements with upstream block valves are provided, it shall be ensured that these are interlocked against inadvertent simultaneous closing of both valves.

3.4.5 Block valves, in particular those in safety systems, shall have status indicators for quick identification of their open/closed condition. Closing times for such valves shall be so that shock waves in the connected piping system are avoided.

3.4.6 Appropriate orifice/valve combinations shall be fitted in the fire mains in order to provide for realistic periodical capacity tests of the fire pumps.
Section 17

Safety Systems

A. General Remarks, Definitions

1. This Section refers to safety systems for fixed installations, mobile units and productions units.

2. Definitions

For the purpose of these Rules the following definitions apply.

2.1 Production

The term production means the entire train of hydrocarbon flow from the subsurface safety valve in a well through the process facilities on the installation and up to and including the import/export pipeline isolating valves.

2.2 Production safety system

The term production safety system means a system for the protection of personnel, the installation and the environment, designed to operate automatically/manually in case of process upsets due to control system disturbance or failure of equipment. The philosophy behind this is to arrange a second line of protection in addition to and independent of the normal process control systems.

2.3 For installations without own production of hydrocarbons, e.g., booster platforms, the above definitions shall be applied by analogy.

2.4 For installations used simultaneously for several purposes or comprising two or more separate units, see also Section 11, D.1.3.

2.5 For drilling and well completion a drilling safety system shall be provided.

3. Scope

3.1 For each installation a clear concept for the safety systems is required. Depending upon its design, the actuation of a safety system will cause

- shutdown of individual components or part of, or the entirety of a production system
- start of emergency systems.

3.2 The production safety system shall be independent of the normal process controls and shall be physically separate from them. In designing a production safety system, the fail-safe principle has to be implemented rigorously, i.e. the process (not only a single component) shall attain the predetermined "most safe" condition upon failure of a control signal or loss of power.

3.3 Drilling safety systems see Section 11, D.

3.4 If, upon indication of an abnormal condition by an alarm or detection by personnel, a process shutdown becomes necessary, all input sources of process streams involved, heat and fuel shall be capable of being shut off or diverted to other sections where they can be handled safely. Process streams shall be provided with means to be shut off at their primary source (well, pump, compressor) in order to avoid a cascading shutdown effect which may result in high stresses on equipment involved.

3.5 Shutdown levels

3.5.1 For the cases as specified in 3.5.2 through 3.5.5 means shall be provided for the actuation of optical and acoustic alarms, supplemented by information through the public address system. Depending upon the size and complexity of the installation, each production safety system shall be graded into different categories assigned to different levels of severity.

A distinction shall also be made between process shutdowns (PSD) caused by process irregularities and emergency shutdowns (ESD) activated in consequence of, e.g., a blow out, uncontrollable release of toxic gases, fire or collision. A proposal for meeting this requirement are the four different levels as specified in 3.5.2 through 3.5.5. For every automatic shutdown action a manual override switch, safeguarded against unauthorized use, shall be provided.

Shutdowns required by drilling activities may be initiated manually, depending on the safety philosophy.

3.5.2 Shutdown level 3 (PSD)

This means an automatic partial shutdown of process sections, e.g., shutdown, isolation and bypassing of a pressure vessel or a shutdown and isolation of one of two parallel process trains. It has to be activated after manual intervention by operator personnel has failed to rectify the fault. A Level 3 shutdown will not affect production totally.
Typical examples for initiation of such a shutdown are excess temperature or pressure, liquid overflow, gas blowby, machinery malfunction.

3.5.3 Shutdown level 2 (PSD)

This PSD has to be activated automatically after manual intervention and/or Level 3 action has failed to control the fault. In a Level 2 situation a total process shutdown under controlled conditions including closure of the installation inlet valve and/or pipeline valves with interruption of all production/process activities will be effected, while all necessary utilities are kept in operation, and emergency systems on standby.

Reasons for causing a Level 2 shutdown are as exemplified in 3.5.2.

3.5.4 Shutdown level 1 (ESD)

This emergency shutdown shall be capable of being initiated manually (e.g., by push button) per unit or plant section, with all consequent steps occurring automatically. This means automatic closure of all entry sources to the facilities (well heads, flow and pipelines, export lines as well as utilities). A Level 1 ESD may be caused by hydrocarbon leakage or a localized fire. It may require the depressurization of some of the equipment.

All electrical equipment except the lift and fire pumps shall be stopped. The diesel fire pump shall be started.

3.5.5 Shutdown level 0 (ESD)

Means for manual initiation by one overall push button or similar, with consequent automatic steps, shall be provided. Additional push buttons connected in parallel shall be arranged at the life boat muster stations and at the helideck. The Level 0 ESD requires a total shut-down of the subject installation, including the subsurface safety valves and/or pipeline isolation valves with automatic depressurization of all process systems. Navigational aids and air traffic lights, both battery powered, shall remain in operation.

A Level 0 ESD may be caused by a blow out, major fire, explosion or ship collision. It may require the evacuation of personnel from the installation.

B. Elements of Safety Systems

1. General

Elements of safety systems necessary to minimize the effects of unintentionally released hydrocarbons include the following:

- gas detection system
- fire detection system
- containment and drain system for liquid hydrocarbons
- systems for the safe discharge of gas to the atmosphere
- emergency shutdown (ESD) system
- subsurface safety valves (SSSV's)

2. Gas detection system

See also Section 10, J. and Chapter 6, Section 9, C.9.

2.1 Gas detectors should be arranged preferably in pairs and located

- in hazardous areas Zone 1 and 2
- in ventilation outlets of Zone 1 and 2
- in the ducts of all ventilation and combustion air intakes

2.2 Each detector shall be capable of actuating a pre-alarm and a main alarm, i.e. at 20 % LEL (Lower Explosive Limit) and of 60 % LEL.

2.3 Means shall be provided to initiate the following safety actions when the gas concentration reaches 60 % LEL:

a) If detected in ventilation inlets:
   - ventilation to be stopped and fire dampers closed
   - all ignition sources to be eliminated
   - non explosion proof electrical equipment to be deenergized

b) If detected in combustion air inlets:
   - boilers, heaters and internal combustion engines to be shutdown, fuel supply to be cut off and fire extinguishing medium to be injected into combustion chambers, ignition sources to be eliminated

c) If detected in ventilation air outlets from hazardous areas:
   - shutdown of all hydrocarbon flow to the area, elimination of all ignition sources inside the area

d) If detected in ventilation inlets to safe areas such as control room or living quarters or in wellhead areas:
   - ESD system to be activated, see A.3.

e) If detected in the drilling area:
   - separate procedures to be considered for each individual installation
3. Fire detection system

3.1 Upon actuation of two or more fire detectors in one fire zone, the following safety functions shall be capable of being initiated automatically:

- stopping of all inflow and release of hydrocarbons to and from the zone, including shut-off of fuel supply for areas containing heaters, boilers or internal combustion engines, except emergency generators, fire water pumps
- fire alarm
- start of fire water pumps
- stopping of ventilation
- closing of fire dampers
- release of deluge system

Drilling operations shall be stopped manually.

3.2 The ESD system is to be activated automatically or by the operator, depending on the safety philosophy.

4. Containment systems

4.1 Relief and containment systems, sufficient in size, strength and fire resistivity, are required for the immediate release of abnormal liquid accumulations due to carry over.

4.2 Means shall be provided for the drainage of leakage or overflow from equipment into closed containment systems.

4.3 These systems shall be equipped with high level alarms as necessary.

5. Systems for the safe discharge of gas to atmosphere

In addition to flare and vent systems for the discharge of gases to the atmosphere under operating conditions provisions shall be made for the safe discharge of gases under abnormal conditions (relief). Suitable knock-out drums and drains have to be provided. See also Section 14.

6. Emergency shutdown (ESD) system

Devices to initiate automatic shutdown actions depending on an abnormal process situation or the detection of fire/gas shall be provided. Facilities for manual release of the ESD action have to be installed in the control station and at strategic positions. The manually operated ESD function shall as far as possible be arranged independent of the automatically operated ESD system.

See A.3. as well as Chapter 6, Section 9, E.

7. Subsurface safety valves

7.1 Subsurface controlled subsurface safety valves (SSCSSV) shall be closed if the well rate exceeds a predetermined rate that might indicate a large leak.

7.2 Surface controlled subsurface safety valves (SCSSV) shall be closed, when activated by

- excess flow
- ESD level 0
- fire or gas loop on wellhead deck

7.3 Attention shall be paid to ensuring that no hazard is presented to drilling operations as a result of ESD initiation on production and processing installations.

C. Special Requirements for Sour Gas Operation

1. General

Attention is drawn to the properties of hydrogen sulphide (H₂S) as one of the most vicious hazards to human life and environment. For more details see also Section 11, E.

2. Design and construction

2.1 As a matter of principle, all facilities and piping systems containing H₂S shall be designed as closed systems. No unburnt H₂S is allowed to be discharged to the atmosphere.

2.2 Major facilities and piping systems have to be divided into sections capable of being isolated in order to reduce the toxic gas volume in case of escape.

2.3 For the selection of materials see Section 15.

3. Flares and ventilation

3.1 In addition to Section 14 and Section 2, C. of these Rules the following requirements have to be observed:

- Spaces between vessels and equipment have to be sufficient in size to allow, to the maximum degree possible, natural and/or artificial ventilation, as well as to give sufficient field of view to allow operators to be observed while working in a hazardous zone (buddy system).
− Mechanical blowers (bug blowers) have to be provided in areas of low natural ventilation or where the release of small quantities of H₂S cannot be prevented (e.g. sampling points, at shale shakers on drilling rigs, sour gas compressors, etc.).

− Flares have to be equipped with a permanently burning pilot flame to ignite immediately any released H₂S volumes. Pilot gas should preferably be sweet gas. The design of flares shall be sufficient to achieve complete combustion even under emergency conditions.

3.2 The height of the flare has to be adequate to ensure the safe distribution and dilution of SO₂.

In cases where the required distribution and dilution cannot be achieved, the installation of an incinerator assisted flare has to be considered.

4. Special requirements for the protection of personnel

4.1 A H₂S warning system shall be provided which causes audible and visual alarms in all areas of the installation or complex where people may be present. A sufficient number of H₂S sensors shall be fitted to cover

− all areas carrying facilities, piping or machinery containing H₂S
− ventilation air intakes to machinery or service spaces, control rooms and accommodations

4.2 Breathing equipment and other means for protection of personnel (eye-wash facilities, showers) are not subject to these Rules. Safety equipment shall be in line with valid national rules and regulations.
### Table A.1  List of Standards, Codes, etc. Quoted

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**Annex A**

List of Standards, Codes, etc. Quoted
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AD Mbl. Arbeitsgemeinschaft Druckgefäße / Merkblätter, Germany  
API American Petroleum Institute  
ASTM American Society for Testing & Materials  
ANSI American National Standard Institute  
AWS American Welding Society  
BS British Standard  
DIN Deutsches Institut für Normung (German Institute for Standardization)  
EL BergV Regulations of the German Mining Authority  
EN European Standard  
FSS Code International Code Fire Safety Systems  
FTP Fire Test Procedure Code  
IEC International Electrotechnical Commission  
IMO International Maritime Organization of the United Nations  
IP Institute of Petroleum  
ISO International Standardization Organization  
LLC Load Line Contention 1966  
MARPOL Protocoll for the Prevention of Pollution from Ships  
MODU Code for the Construction and Equipment of Mobile Offshore Drilling Units, issued by IMO  
NACE National Association of Corrosion Engineers  
SOLAS International Convention for the Safety of Life at Sea, issued by IMO  
UVV Accident Prevention Regulations of the See-BG, Germany