RULES FOR CLASSIFICATION

Inland navigation vessels

Edition December 2015

Part 4 Systems and components

Chapter 3 Pressure vessels
FOREWORD

DNV GL rules for classification contain procedural and technical requirements related to obtaining and retaining a class certificate. The rules represent all requirements adopted by the Society as basis for classification.

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CHANGES – CURRENT

This is a new document.
The rules enter into force 1 July 2016.
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SECTION 1 PRESSURE VESSELS AND HEAT EXCHANGERS, BOILERS AND THERMAL OIL HEATERS

1 Pressure vessels and heat exchangers

1.1 General

1.1.1 Scope

The following requirements apply to pressure vessels for the operation of the main propulsion plant and its auxiliary machinery. They also apply to pressure vessels and equipment necessary for the operation of the inland waterway vessel and to independent cargo tanks if these are subjected to internal or external pressure in service.

Cargo tanks and containers with design temperatures of < 0°C are subject to Pt.6 Ch.1 Sec.3.

These requirements do not apply to pressure vessels with permitted working pressures of up to 1.0 bar and with a total capacity, without deducting the volume of internal fittings, of not more than 1000 litres, nor to pressure vessels with working pressures of > 1 bar where the product of pressure [bar] times capacity [litres] is ≤ 200.

Manufacture and inspection of these pressure vessels are subject to the engineering practice.

Pressure vessels manufactured to recognized standards can be accepted if they have been subjected in the manufacturer’s works to tests conforming to the standard.

1.1.2 Division into classes

Pressure vessels shall be assigned to classes in accordance with the operating conditions indicated in Table 1.

Pressure vessels filled partly with liquids and partly with air or gases or which are blown out with air or gases, such as pressure tanks in drinking water or sanitary systems and reservoirs, shall be classified as pressure vessels containing air or gas.

Table 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>Liquefied gases (propane, butane, etc.), toxic and corrosive media</td>
<td>all</td>
<td>NA</td>
</tr>
<tr>
<td>Steam, compressed air, gases, thermal oil</td>
<td>$p_c &gt; 16$ or $t &gt; 300$</td>
<td>$p_c \leq 16$ and $t \leq 300$</td>
</tr>
<tr>
<td>Liquid fuels, lubricating oils, flammable hydraulic fluids</td>
<td>$p_c &gt; 16$ or $t &gt; 150$</td>
<td>$p_c \leq 16$ and $t \leq 150$</td>
</tr>
<tr>
<td>Water, non-flammable hydraulic fluids</td>
<td>$p_c &gt; 40$ or $t &gt; 300$</td>
<td>$p_c \leq 40$ and $t \leq 300$</td>
</tr>
<tr>
<td>Pressure vessel class</td>
<td>I</td>
<td>II</td>
</tr>
</tbody>
</table>

NA = not applicable
1.1.3 Documents for approval
Drawings of pressure vessels, heat exchangers and pressurized equipment containing all the data necessary for their safety assessment shall be submitted to the Society. The following details, in particular, shall be specified:
— intended use, substances to be contained in the vessel
— maximum allowable working pressure and temperatures; if necessary, secondary loads and the volume of the individual pressure spaces
— design details of the pressurized parts
— substance to be contained in the pressure vessel, working pressures and temperatures
— materials to be used, welding details, heat treatment.

1.2 Materials

1.2.1 General requirements
The materials for pressure vessels shall be suitable for the intended use and shall comply with Pt.2.
Parts such as gussets, girders, lugs, brackets etc. welded directly to pressure vessel walls shall be made of a material compatible with that of the wall and of guaranteed weldability.
Welded structures are also subject to Pt.2.

1.2.2 Testing of materials
Tests in accordance with Pt.2 are prescribed for materials belonging to pressure vessel classes I and II used for:
a) All surfaces under pressure with the exception of small parts such as welded pads, reinforcing discs, branch pieces and flanges of nominal diameter ≤ DN 32 mm, together with 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 the maximum allowable working pressure, PB [bar] by the nominal diameter, DN [mm] is < 2500 or the nominal diameter DN is > 250

c) Bolts and nuts of size M 30 (30 mm diameter metric thread) and above made of steels with a tensile strength of more than 500 N/mm², or more than 600 N/mm² in the case of nuts, and alloy or heat-treated steel bolts above M 16.

1.2.3 For class II parts subject to mandatory testing, proof of material quality may take the form of works inspection certificates 3.1 according to EN 10204 provided that the test results certified therein comply with Pt.2.
Works inspection certificates may also be recognized for series-manufactured class I parts made of unalloyed steels, e.g. hand- and manhole covers, and for branch pipes where the product of PB × DN ≤ 2500 and the nominal bore DN ≤ 250 mm for service temperatures of < 300°C.

1.2.4 For all parts not subject to testing of materials by the Society, alternative proof of the characteristics of the material is to be provided, e.g. a works certificate or manufacturer’s guarantee as to the properties of the materials used.

1.3 Manufacturing principles

1.3.1 Manufacturing processes applied to materials
Manufacturing processes shall be compatible with the materials concerned. Materials whose grain structure has been adversely affected by hot or cold working are to undergo heat treatment in accordance with Pt.2.
1.3.2 Welding
The execution of welding work, the approval of welding shops and the qualification testing of welders shall be in accordance with Pt.2.

1.3.3 Reinforcement of openings
Due account shall be taken of the weakening of walls caused by openings and, where necessary, reinforcement shall be provided.

1.3.4 End plates
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.
Where covers or ends are secured by hinged bolts, the latter shall be safeguarded against slipping off.

1.3.5 Branch pipes
The wall thickness of branch pipes shall be so dimensioned as to enable additional external stresses to be safely absorbed. The wall thickness of welded-in branch pipes should be appropriate to the wall thickness of the part into which they are welded. The walls shall be effectively welded together.
Pipe connections in accordance with Ch.2 Sec.2 shall be provided for the attachment of piping.

1.3.6 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 shall be such as to ensure the proper execution of the expansion process and the sufficient anchorage of the tubes. The expanded length should not be less than 12 mm.

1.3.7 Compensation for expansion
The design of pressure vessels and equipment is to take account of possible thermal expansion, e.g. between the shell and nest of heating tubes.

1.3.8 Corrosion protection
Pressure vessels and equipment exposed to accelerated corrosion due to the medium which they contain shall be protected in a suitable manner.

1.3.9 Cleaning and inspection
Pressure vessels and equipment shall be provided with inspection and access openings which should be as large as possible and conveniently located. For the minimum dimensions of these, see [2.3].
Pressure vessels over 2.0 m long shall have inspection openings at each end at least. Where the pressure vessel can be entered, one access opening is sufficient.
Pressure vessels with an inside diameter of more than 800 mm shall be capable of being entered.
In order to provide access with auxiliary or protective gear, 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.
Inspection openings may be dispensed with where experience has proved the unlikelihood of corrosion or deposits, e.g. in steam jackets.
Where pressure vessels and equipment contain dangerous substances (e.g. liquefied or toxic gases), the covers of inspection and access openings shall not be secured by crossbars but by bolted flanges.
Special inspection and access openings are not necessary where internal inspection can be carried out by removing or dismantling parts.

1.3.10 Mountings
Wherever necessary, strengthening elements are to be fitted at mountings and supports to prevent excessive stress increases in the pressure vessel shell due to vibration.
1.3.11 Identification and marking
Each pressure vessel shall be provided with a plate or permanent inscription indicating the manufacturer, the serial number, the year of manufacture, the capacity, the maximum allowable working pressure of the pressurized parts and the identification of the inspection body. On smaller items of equipment, an indication of the working pressures is sufficient.

1.4 Design
Design calculations shall be performed according to the Society’s rules or to international standards accepted by the Society, taking into consideration the special requirements for pressure vessels installed on inland waterway vessels.
Applicable statutory requirements of the flag state authority are to be observed additionally.

1.5 Equipment and installation

1.5.1 Shut-off devices
Shut-off devices shall 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 pressure 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 pressure vessels should 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.

1.5.2 Pressure gauges
Each pressure vessel which can be shut-off and every group of pressure vessels with a shutoff device shall be equipped with a pressure gauge, also capable of being shut-off, suitable for the medium contained in the pressure vessels. The measuring range and calibration shall extend to the test pressure with a red mark to indicate the maximum working pressure.
Equipment need only be fitted with pressure gauges when these are necessary for its operation.

1.5.3 Safety equipment

1.5.3.1 Each pressure vessel which can be shut-off or every group of pressure vessels with a shut-off device shall be equipped with a spring-loaded safety valve which cannot be shut-off and which closes again reliably after blow-off.
Appliances for controlling pressure and temperature are no substitute for relief valves.

1.5.3.2 Safety valves shall be designed and set in such a way that the max. allowable working pressure cannot be exceeded by more than 10%. Means shall be provided to prevent the unauthorized alteration of the safety valve setting. Valves cones shall be capable of being lifted at all times.

1.5.3.3 Means of drainage which cannot be shut-off shall be provided at the lowest point on the discharge side of safety valves for gases, steam and vapours. Facilities shall 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.

1.5.3.4 Steam-filled spaces shall be fitted with a safety valve if the steam pressure inside them is liable to exceed the maximum allowable working pressure. If vacuum will occur, e.g. by condensate, an appropriate safety device is necessary.

1.5.3.5 Heated spaces which can be shut off on both the inlet and the outlet side shall 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.
1.5.3.6 Pressure water tanks shall 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 its maximum allowable working pressure.

1.5.3.7 Calorifiers shall be fitted with a safety valve at the cold water inlet.

1.5.3.8 Rupture disks are permitted only with the consent of the Society in application where their use is specially justified. They must be designed that the maximum allowable working pressure $P_B$ cannot be exceeded by more than 10%.

Rupture disks shall be provided with a guard to catch the fragments of the rupture element and shall 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.

1.5.3.9 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 pressure-volume product is $P_B \times \text{capacity [litres]} \leq 200$.

1.5.3.10 Electrically heated equipment shall be equipped with a temperature limiter besides of a temperature controller.

1.5.3.11 Oil-fired warm water generators are to be equipped with limiters for temperature and pressure above a specified threshold. Additionally, a low water level limiter, a limiter for minimum pressure or a low flow limiter shall be provided. The actuation of the limiters shall shut-down and interlock the oil burner.

Warm water generators heated by exhaust gases shall be equipped with the corresponding alarms.

1.5.3.12 The equipment on pressure vessels shall be suitable for the use on inland navigation vessels. The limiters for e.g. pressure, temperature and flow are safety devices and have to be type-approved and have to be provided with appropriate type approval certificates. For type approval of safety valves, the test requirements outlined in ISO/ EN 4196 shall be observed.

1.5.4 Liquid level indicators and feed equipment for heated pressure vessels

1.5.4.1 Heated pressure vessels in which a fall of the liquid level can result in unacceptably high temperatures in the vessel walls shall be fitted with a device for indicating the level of the liquid.

1.5.4.2 Pressure vessels with a fixed minimum liquid level shall be fitted with feed equipment of adequate size.

1.5.4.3 Warm water generating plants shall be designed as closed systems with external pressure generation and membrane expansion vessel. Water shall be circulated by forced circulation.

1.5.5 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 shall be protected against mechanical damage, e.g. by wire mesh. With combustible, explosive or poisonous media, sight glasses shall be fitted with closable covers.

1.5.6 Draining and venting

Pressure vessels and equipment shall be capable of being depressurized and completely emptied or drained. Particular attention shall be given to the adequate drainage facilities of compressed air pressure vessels.

Suitable connections and a vent at the uppermost point shall be provided for the execution of hydraulic pressure tests.
1.5.7 Installation
Pressure vessels and equipment shall 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 shall be fitted inside pressure vessels.

Wherever possible, horizontal compressed air receivers should be installed at an angle and parallel to the fore-and-aft line of the inland waterway vessel. The angle should be at least 10° (with the valve head at the top.) Where pressure vessels are installed athwartships, the angle should be greater.

Where necessary, compressed air receivers shall be so marked on the outside that they can be installed on board inland waterway vessels in the position necessary for complete venting and drainage.

1.5.8 Cargo tanks for liquefied gases
For the equipment and installation of cargo tanks for liquefied gases, see Pt.6 Ch.1 Sec.3.

1.6 Tests

1.6.1 Constructional test and pressure tests
On completion, pressure vessels and equipment are to undergo constructional and hydrostatic tests. No permanent deformation of the walls may result from these tests.

During the hydrostatic test, the loads specified in Table 2 may not be exceeded.

For Group I pressure vessels and equipment, the test pressure is generally 1.5 times the permitted working pressure subject to a minimum of p + 1 bar.

For pressure vessels and equipment of groups II and III, the test pressure is 1.3 times the permitted working pressure subject to a minimum of p + 1 bar. For working pressures below atmospheric pressure, the test pressure is 2 bar excess pressure.

Air coolers (e.g. charge air coolers) shall be tested on the water side at 1.5 times the permitted working pressure subject to a minimum of 4 bar.

In special cases the use of media other than water for the pressure tests may be agreed.

Table 2 Loads during hydrostatic tests

<table>
<thead>
<tr>
<th>For materials with a definite yield point</th>
<th>For materials without a definite yield point</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{eh,20}$ / 1.1</td>
<td>$R_{m,20}$ / 2.0</td>
</tr>
</tbody>
</table>

$R_{eh,20}$ = guaranteed yield strength or minimum value of the 0.2% proof stress at room temperature

$R_{m,20}$ = guaranteed minimum tensile strength [N/mm$^2$] at room temperature

1.6.2 Tightness tests
Where pressure vessels and equipment contain hazardous substances (e.g. liquefied gases), the Society reserves the right to call for a special test of gastightness.

1.6.3 Certification of tests
The constructional test and the pressure test shall be performed in the manufacturer’s works in the presence of a surveyor. For pressure vessels and equipment of group II and III the manufacturer’s test certificates are acceptable if the permitted working pressure $PB \leq 1$ bar or if the product of the pressure [bar] x capacity [litres] $PB \times l \leq 200$

1.6.4 Testing after installation on board
After installation on board the fittings of pressure vessels and equipment and the arrangement and settings of the safety devices shall be checked and, wherever necessary, subjected to a functional test.
2 Steam boilers

2.1 General

2.1.1 Scope
For the purpose of these rules the term "steam boiler" includes all closed pressure vessels and piping systems used for:

a) generating steam with a pressure above atmospheric pressure (steam generators) – the generated steam shall be used in a system outside of the steam generators or

b) raising the temperature of water above the boiling point corresponding to atmospheric pressure (hot water generators) – the generated hot water shall be used in a system outside of the hot water generators.

The term "steam boiler" also includes any equipment directly connected to the aforementioned pressure vessels or piping systems in which the steam is, for example, superheated or cooled, as well as external drums, and the circulating lines and the casings of circulating pumps serving forced-circulation boilers.

For warm water generators having a maximum allowable discharge temperature of not more than 120°C and steam or for hot water generators which are heated solely by steam or hot liquids 1 applies.

2.1.2 Other rules
As regards their construction and installation, steam boiler plants are also required to comply with the applicable statutory requirements and regulations of the inland waterway vessel's country of registration.

2.1.3 Definitions
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.

The maximum allowable working pressure PB (design pressure) is the approved steam pressure in bar (gauge 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.

The heating surface is that part of the boiler walls through which heat is supplied to the system, i.e.:

a) the area \([m^2]\) measured on the side exposed to fire or exhaust gas, or

b) in the case of electrical heating, the equivalent heating surface \([m^2]\):

\[
H = \frac{860 \cdot P}{18000} [m^2]
\]

\[P = \text{electrical power \([kW]\)}\]

The allowable steam output is the maximum hourly steam quantity which can be produced continuously by the steam generator operating under the design steam conditions.

The “dropping time” is the time taken by the water level under conditions of interrupted feed and allowable steam production, to drop from the lowest water level (LWL) to the level of the highest flue (HF).

\[
T = \frac{V}{D \cdot V} \text{[min]}
\]
The following symbols shall be used:

\[ T = \text{dropping time [min]} \]
\[ V = \text{volume [m}^3\text{]} \text{ of water between the lowest water level and the highest flue} \]
\[ D = \text{allowable steam output [kg/min]} \]
\[ v' = \text{specific volume of water at saturation temperature [m}^3\text{/kg]} \]

The lowest water level shall be set so that the dropping time is not less than 5 minutes.

2.1.4 Manual operation
For steam boilers which are operated automatically means for operation and supervision shall be provided which allow manual operation with the following minimum requirements by using an additional control level:

At boilers with a defined highest flue at their heating surface (e.g. oil-fired steam boilers and exhaust gas boilers with temperature of the exhaust gas > 400°C) at least the water level limiters, and at hot water generators the temperature limiters, have to remain active.

The monitoring of the oil content of the condensate or of the ingress of foreign matters into the feeding water may not lead to a shut-down of the feeding pumps during manual operation.

The safety equipment not required for manual operation may only be deactivated by means of a key-operated switch. The actuation of the key-operated switch is to be indicated.

For detailed requirements in respect of manual operation of the oil firing system, see [4].

Manual operation demands constant and direct supervision of the steam boiler plant.

2.1.5 Documents for approval
The following documents shall be submitted for approval.

— drawings of all steam boiler parts subject to pressure, such as shells, drums, headers, tube arrangements, manholes and inspection covers, etc.,
— drawings of the expansion vessel and other pressure vessels for hot water generating plants
— equipment and functional diagrams with description of the steam boiler plant
— circuit diagrams of the electrical control system and, as applicable, monitoring and safety devices with limiting values.

These drawings shall contain all the data necessary for strength calculations and design assessment, such as maximum allowable working pressure, heating surfaces, lowest water level, allowable steam production, steam conditions, superheated steam temperatures, as well as materials to be used and full details of welds.

Further the documents shall contain information concerning the equipment of the steam boiler as well as a description of the boiler plant with the essential boiler data, information about the installation location in relation to the longitudinal axis of the ship and data about feeding and oil firing equipment.

2.2 Materials

2.2.1 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.

2.2.2 Approved materials
The requirements specified in [2.2.1] are recognized as having been complied with if the materials shown in Table 3 are used.

Materials not specified in Pt.2 may be used provided that proof is supplied of their suitability and mechanical properties.
### 2.2.3 Material testing

The materials of boiler parts subject to pressure shall be tested under supervision of the Society in accordance with the Pt.2 (see Table 3). For these materials, an A-Type certificate shall be issued.

**Table 3 Approved materials**

<table>
<thead>
<tr>
<th>Material and product form</th>
<th>Limits of application</th>
<th>Material grade in accordance with Part 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel plates and strips</td>
<td>NA</td>
<td>Steel plates for steam boilers and pressure vessels</td>
</tr>
<tr>
<td>Steel tubes</td>
<td>NA</td>
<td>Steel pipes for high temperatures service</td>
</tr>
<tr>
<td>Steel forgings and formed parts</td>
<td>NA</td>
<td>Steel forgings for steam boilers and pressure vessels</td>
</tr>
<tr>
<td>Steel castings</td>
<td>NA</td>
<td>Steel castings for steam boilers and pressure vessels</td>
</tr>
<tr>
<td>Nodular cast iron</td>
<td>≤ 300°C  ≤ 40 bar ≤ DN 175 for valves and fittings</td>
<td>Nodular graphite iron castings</td>
</tr>
<tr>
<td>Lamellar (grey) cast iron:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>boiler parts only for unheated surfaces</td>
<td>≤ 200°C ≤ 10 bar Φ ≤ 200</td>
<td>Grey iron castings</td>
</tr>
<tr>
<td>and not for thermal oil heaters</td>
<td>≤ 200°C ≤ 10 bar ≤ DN 175</td>
<td></td>
</tr>
<tr>
<td>valves and fittings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolts and nuts</td>
<td>NA</td>
<td>Bolts and nuts for elevated temperature</td>
</tr>
<tr>
<td>Valves and fittings of copper alloy</td>
<td>≤ 225°C ≤ 25 bar</td>
<td>Copper alloy castings</td>
</tr>
<tr>
<td>castings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Φ = diameter [mm]

NA = not applicable

Material testing under supervision of the Society may be waived in the case of:

a) small boiler parts made of unalloyed steels, such as stay bolts, stays of ≤ 100 mm diameter, reinforcing plates, handhole, headhole and manhole closures, forged flanges up to DN 150 and nozzles up to DN150 and

b) smoke tubes (tubes subject to external pressure).

For the parts mentioned in a) and b), the properties of the materials shall be attested by Manufacturer Inspection Certificates.

If the design temperature is 450°C or higher or the design pressure is 32 bar or higher, pipes shall be non-destructively tested in accordance with Pt.2 Ch.4 Sec.7.

Special agreements may be made regarding the testing of unalloyed steels to recognized standards.

The materials of valves and fittings shall be tested under supervision of the Society in accordance with the data specified in Table 4. For these materials, an A-Type certificate needs to be issued.

Parts not subject to material testing, such as external supports, lifting brackets, pedestals, etc. shall be designed for the intended purpose and shall be made of suitable materials.
### Table 4 Testing of materials for valves and fittings

<table>
<thead>
<tr>
<th>Type of material</th>
<th>Service temperature</th>
<th>Testing required for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel, cast steel</td>
<td>&gt; 300</td>
<td>DN &gt; 32</td>
</tr>
<tr>
<td>Steel, cast steel Nodular cast iron</td>
<td>≤ 300</td>
<td>$p_{perm} \times DN &gt; 2500$ or DN &gt; 250</td>
</tr>
<tr>
<td>Copper alloys</td>
<td>≤ 225</td>
<td>$p_{perm} \times DN &gt; 1500$</td>
</tr>
</tbody>
</table>

$P_{perm} = \text{working pressure [bar]}$

$DN = \text{nominal diameter [mm]}$

1. No tests are required for grey cast iron
2. Testing may be dispensed with if the nominal DN is ≤ 32

#### 2.3 Principles applicable to manufacture

**2.3.1 Manufacturing processes applied to boiler materials**

Materials shall be checked for defects during the manufacturing process. Care shall be taken to ensure that different materials cannot be confused. 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 regulations.

Steam boiler parts whose microstructure has been adversely affected by hot or cold forming shall be subjected to heat treatment and testing in accordance with Pt.2.

**2.3.2 Welding**

Steam boilers shall be manufactured by welding.

The execution of welds, the approval of welding shops and the qualification testing of welders shall be in accordance with the Society’s rules.

**2.3.3 Tube expansion**

Tube holes shall be carefully drilled and deburred. Sharp edges shall 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 shall be cleaned and checked for size and possible defects. Where necessary, tube ends shall be annealed before being expanded.

Smoke tubes with welded connections between tube and tube plate at the entry of the second path shall be roller-expanded before and after welding.

**2.3.4 Stays, stay tubes and stay bolts**

Stays, stay tubes and stay bolts shall be so arranged that they are not subjected to undue bending or shear forces.

Stress concentrations at changes in cross-section, in threads and at welds shall be minimized by suitable component geometry.

Stay bars and stay bolts shall be welded preferably by full penetration. Any vibrational stresses shall be considered for longitudinal stays.

Stay bars and stay bolts shall 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.
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 shall be minimized by suitable component geometry. Welds shall be executed as full penetration welds. In fire tube boilers, gusset stays shall be located at least 200 mm from the fire tube.

Where flat surfaces exposed to flames are stiffened by stay bolts, the distance between centres of the said bolts shall not generally exceed 200 mm.

**2.3.5 Stiffeners, straps and lifting eyes**

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.

Doubling plates may not be fitted at pressure parts subject to flame radiation.

Where necessary to protect the walls of the boiler, strengthening plates shall be fitted below supports and lifting brackets.

**2.3.6 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 ≥ 15 mm. The end/shell wall thickness ratio \( s_B/s_M \) shall not be greater than 1.8. The end shall be welded to the shell with a full penetration weld.

**2.3.7 Nozzles and flanges**

Nozzles and flanges shall be of rugged design and properly welded, preferably by full penetration to the shell. The wall thickness of nozzles shall be sufficiently large 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 shall be made of forged material with favourable grain orientation.

**2.3.8 Cleaning and inspection, openings, cut-outs and covers**

Steam boilers shall 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, shall be provided with means of access.

Parts inside drums shall not obstruct internal inspection or shall be capable of being removed.

Inspection and access openings are required to have the following minimum dimensions (see Table 5):

<table>
<thead>
<tr>
<th>Table 5 Opening dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manholes</strong></td>
</tr>
<tr>
<td><strong>Holes for the head</strong></td>
</tr>
<tr>
<td><strong>Handholes</strong></td>
</tr>
<tr>
<td><strong>Sight holes</strong></td>
</tr>
</tbody>
</table>

The edges of manholes and other openings, e.g. for domes, shall be effectively reinforced if the plate has been unacceptably weakened by the cut-outs. The edges of openings closed with covers shall be reinforced by welded on edge-stiffeners.

Cover plates, manhole frames and crossbars shall 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 shall 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 shall 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.

Only continuous rings may be used as packing. The materials used shall be suitable for the given operating conditions.

### 2.4 Design

Design calculations are to be performed according to existing the Society's rules or to international codes accepted by the Society such as AD-Merkblätter, ASME, CODAP, British standards or harmonized European standards, taking into consideration the special requirements for steam boilers installed on inland waterway vessels.

Applicable statutory requirements of the flag state authority are to be observed additionally.

### 2.5 Equipment and installation

#### 2.5.1 Feed and circulating equipment

Each boiler shall generally be provided with two feed-water pumps, each of which shall be capable of supplying a quantity of water equivalent to 1.25 times the boiler output.

One feedwater pump is sufficient for boilers which are not needed to keep the machinery in operation, provided that the following conditions are met:

a) The steam pressure and the water level shall be automatically controlled.
b) After the firing has been shut-down, the heat stored in the boiler may not cause any inadmissible lowering of the water level.
c) In the event of a failure of the power supply to the feedwater pump drive, the firing system shall shut-down automatically.
d) The boiler shall be fitted with a water-level limiting device independent of the water-level control.

In the case of continuous-flow boilers a pump delivery rate equal to 1.0 times the boiler output is sufficient.

The feedwater system shall be capable both of supplying the required quantity of feedwater against the maximum allowable working pressure and of delivering the quantity of feedwater corresponding to the steaming capacity against 1.1 times the maximum allowable working pressure.

For electrically driven feedwater pumps, each motor shall be supplied via a separate line from the bus-bar.

Each feedwater pump shall be independently capable of being isolated from the suction and delivery lines.

Each boiler feed line shall be equipped with a shut-off device and a non-return valve. If the shut-off device and the non-return valve are not mounted in immediate conjunction, the intervening length of pipe shall be fitted with a pressure relief device.

Continuous-flow boilers require no shut-off device or non-return valve provided that the feed system serves only one boiler.

The feed devices shall be fitted to the steam generator 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.

The feedwater shall be fed into the steam generator in such a way as to prevent damaging effects to the boiler walls and to heated surfaces.

Each forced-circulation boiler shall generally be equipped with two independently driven circulating pumps. Failure of the circulating unit in service shall trip an alarm.

One circulating pump is sufficient for continuous-flow boilers.

Should the power supply to the circulating pump drive fail, the firing shall shut-down automatically.

#### 2.5.2 Shut-off devices

Each steam boiler shall be capable of being shut off from all connected pipes. The shut-off devices shall be installed as close as possible to the boiler shell and are to be operated without risk.
2.5.3 Scum removal, sludge removal, drain, venting and sampling devices
Steam boilers and external steam drums shall be fitted with devices to allow them to be drained and vented and the sludge to be removed. Where necessary, steam generators shall be fitted with a scum removal device.

Drain devices and their connections shall be protected from the effects of the heating gases and shall be capable of being operated without risk. Self-closing sludge removal valves shall be lockable when closed or, alternatively, an additional shut-off device shall be fitted in the pipe.

With the exception of once-through forced-flow steam generators, devices for taking samples from the water contained in the steam generator shall be fitted to the generator.

Scum removal, sludge removal, drain, venting and sampling devices shall be capable of safe operation. The media being discharged shall be drained away safely.

2.5.4 Safety valves
Each steam boiler which has its own steam space shall be equipped with at least two type-approved, spring-loaded safety valves. At least one safety valve shall 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 generator during continuous operation without the maximum allowable working pressure being exceeded by more than 10%.

The closing pressure of the safety valves shall be not more than 10% below the response pressure.

The minimum flow diameter of the safety valves shall be at least 15 mm.

The safety valves shall be fitted to the saturated steam part or, in the case of steam boilers which do not have their own steam space, to the highest point of the boiler or in the immediate vicinity.

The steam may not be supplied to the safety valves through pipes in which water may collect.

A drain which cannot be shut off shall be fitted at the lowest point at the discharge side of the safety valve.

2.5.5 Water level indicators
Each steam with a free surface is to be equipped with at least two indicators giving a direct reading of the water level.

Cylindrical glass water level gauges are not permitted.

The water level indicators shall be fitted so that a reading of the water level is possible when the ship is heeling and during the motion of the inland waterway vessel when it is at sea. The limit for the lower visible range shall be at least 30 mm above the highest flue, but at least 30 mm below the lowest water level. The lowest water level shall not be above the centre of the visible range.

Water level indicators shall be separately and individually connected to the boiler. The connecting lines shall be free from sharp bends so as to avoid water and steam pockets, and shall be safeguarded against the effects of the heated gases and against cooling.

The connection pipes shall have an inner diameter of at least 20 mm. Where water level indicators are linked by means of common connection pipes or where the connection pipes on the water side are longer than 750 mm, the inside diameter of these pipes shall be at least 40 mm.

Water level indicators shall be connected to the water and steam space of the steam boiler by means of quick-acting shut-off devices that are easily accessible and simple to control.

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 discharged media shall be drained away safely.

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 oil burner may be provided in place of the second warning device.

2.5.5.1 Lowest water level

The lowest water level (LWL) shall be located at least 150 mm above the highest flue, even when the ship heels 4° to either side.
The highest flue (HF) shall remain wetted even when the ship is at the static heeling angles laid down in Ch.1 Sec.1 Table 1.

The height of the water level is crucial to the response of the water level limiters. The lowest specified water level shall be indicated permanently on the boiler shell by means of a water level pointer. The location of the pointer shall be included in the documentation for the operator. Reference plates shall be attached additionally beside or behind the water level gauges pointing at the lowest water level.

The highest flue (HF)
— 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, and
— shall be defined by the boiler manufacturer in such a way that, after shut-down of the burner from full-load condition or reduction of the heat supply from the engine, the flue gas temperature or exhaust gas temperature, as applicable, is reduced to a value below 400°C at the level of the highest flue, before, under the condition of interrupted feedwater supply, the water level has dropped from the lowest water level to a level 50 mm above HF.

The highest flue on water tube boilers with an upper steam drum is the top edge of the highest gravity tubes. The requirements relating to the highest flue do not apply to:
— water tube boiler risers up to 102 mm outer diameter
— flues in which the temperature of the heating gases does not exceed 400 °C at maximum continuous power
— once-through forced flow boilers
— superheaters.

The heat accumulated in furnaces and other heated boiler parts may not lead to any inadmissible lowering of the water level due to subsequent evaporation when the oil burner is switched off.

This requirement with regard to an inadmissible lowering of the water level is met for example, if it has been demonstrated by calculation or trial that, after shut-down of the burner from full-load condition or reduction of the heat supply from the engine, the flue gas temperature or exhaust gas temperature, as applicable, is reduced to a value below 400°C at the level of the highest flue, before, under the condition of interrupted feedwater supply, the water level has dropped from the lowest water level LWL to a level 50 mm above the highest flue HF.

The water level indicators shall be arranged in such a way that the distance 50 mm above HF can be identified.

2.5.6 Pressure indicators

Each steam boiler shall be fitted with at least one pressure gauge directly connected to the steam space. The maximum allowable working pressure shall be marked on the dial by means of a permanently and easily visible red mark. The indicating range of the pressure gauge shall include the test pressure.

At least one additional pressure indicator having a sensor independent from the pressure gauge shall be located at the machinery control station or at some other appropriate site.

The pipe to the pressure gauge shall have a water trap and shall be provided with a blow-through connection. 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 close to the connection piece of the pressure gauge pipes.

Pressure gauges shall be protected against radiant heat and shall be well illuminated.

2.5.7 Name plate

A name plate shall be permanently affixed to each steam boiler, displaying the following information:
— manufacturer’s name and address
— serial number and year of construction
— maximum allowable working pressure [bar]
— allowable steam production [kg/h] or [t/h].
The name plate shall be attached to the largest part of the boiler or to the boiler frame so that it is visible.

### 2.5.8 Special requirements for low capacity boilers

In the case of boilers with a water volume of not more than 150 litres and a permitted working pressure of up to 10 bar and where the volume of water in litres multiplied by the max. allowable working pressure in bar does not exceed 500 bar · L, the second feed pump and the second water level indicator, or for continuous-flow boilers the second warning device, may be dispensed with.

### 2.5.9 Special requirements for automatically controlled steam boilers not under permanent supervision

With the exception of steam boilers which are heated by exhaust gas, steam boilers shall be operated with rapid-control, automatic oil burners.

After the oil burner has been shut down, the heat stored in the firebox and the heating gas paths may not cause any inadmissible evaporation of the water contained in the steam generator.

The control system shall be capable of adapting the boiler to changes in the operating load without actuating the safety devices.

The steam pressure shall be automatically regulated by controlling the supply of heat. The steam pressure of boilers heated by exhaust gas may also be regulated by condensing the excess steam.

In the case of steam generators which have a specified minimum water level, the water level shall be regulated automatically by controlling the supply of feedwater.

In the case of forced-circulation steam generators whose heating surface consists of a steam coil and of once-through forced flow steam generators, the supply of feedwater may be regulated as a function of fuel supply.

Fired steam generators shall be equipped with a pressure limiter which cuts out and interlocks the oil burner before the maximum allowable working pressure is reached.

In steam generators on whose heating surfaces a highest flue is specified, two mutually independent water level limiters have to respond to cut out and interlock the oil burner when the water falls below the specified minimum water level.

In the case of forced-circulation steam generators with a specified lowest water level, two mutually independent safety devices shall be fitted in addition to the requisite water level limiters, which will cut out and interlock the oil burner in the event of any unacceptable reduction in water circulation.

In the case of forced-circulation steam generators where the heating surface consists of a single coil and once-through steam generators, two 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 out and interlocking the oil burner.

Where there is a possibility of oil or grease getting into the steam, condensate or hot water system, a suitable automatic and continuously operating unit shall be installed which trips an alarm and cuts off the feedwater supply or the circulation resp. if the concentration at which boiler operation is put at risk is exceeded. The control device for oil or grease ingress may be waived for a dual circulation system.

Where there is a possibility of acid, lye or seawater getting into the steam, condensate or hot water system, a suitable automatic and continuously operating unit shall be installed which trips an alarm and cuts off the feedwater supply or the circulation, as applicable, if the concentration at which boiler operation is put at risk is exceeded. The control device for acid, lye or seawater ingress may be waived for a dual circulation system.

The controls for steam pressure and water level and any additional safety devices (trips) shall take the form of mutually independent units.

The safety devices have to trip visual and audible alarms at the steam boiler control panel.

The electrical devices associated with the limiters shall be designed in accordance with the closed-circuit principle so that, even in the event of a power failure, the limiters will cut out and interlock the systems unless an equivalent degree of safety is achieved by other means.

The electrical interlocking of the oil burner following tripping by the safety devices shall only be cancelled out at the oil burner control panel itself.
The receptacles for water level limiters located outside the steam boiler shall be connected to the steam 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 have to 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 are to have an inner diameter of at least 40 mm.

Operation of the oil burner shall only be possible when the shut-off devices are open or else, after closure, the shut-off devices are reopening automatically and in a reliable manner.

Water level limiter receptacles which are located outside the steam boiler shall be designed in such a way that a compulsory and periodic blow-through of the receptacles and lines is carried out.

Emergency shut-down of the oil burner shall be possible from the burner control platform.

If an equivalent level of safety cannot be achieved by the self-monitoring of the equipment, the functional testing of the safety devices shall be practicable even during operation. In this case, the operational testing of the water level limiters shall be possible without dropping the surface of the water below the lowest water level (LWL).

2.5.10 Design and testing of valves and fittings

Valves and fittings for boilers shall be made of ductile materials as specified in Table 3 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 3, but shall 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 shall be carried out as specified in Table 4. 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.

All valves and fittings shall 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 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. 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.

Safety valves shall be subjected to a test of the set pressure. After the test the tightness of the seat shall be checked at a pressure 0.8 times the set pressure. The setting shall be secured against unauthorized alteration.

2.5.11 Installation of boilers

Steam boilers shall be installed in the inland waterway vessel with care and shall be secured to ensure that they cannot be displaced by any of the circumstances arising when the inland waterway vessel is at sea. Means shall be provided to accommodate the thermal expansion of the boiler in service. Boilers and their seatings shall be well accessible from all sides or shall be easily made accessible.

Safety valves and shut-off mechanisms shall be capable of being operated without danger. Wherever necessary, permanent steps, ladders or platforms shall be fitted. Water level indicator cocks and valves, except safety valves, which cannot be directly reached by hand from the floor plates or a platform shall be fitted with draw rods or chains enabling them to be operated from the boiler control platform. Cocks shall be so arranged that they are open when the draw rod is in its lowest position.

2.6 Testing of boilers

2.6.1 Manufacturing test

After completion, steam boilers are to undergo a constructional check.

The constructional check includes verification that the steam boiler complies with the approved drawings and is of satisfactory construction. For this purpose, all parts of the boiler shall be accessible to allow adequate inspection. If necessary, the constructional check shall be performed at separate stages of manufacture.
The following documents shall 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.

2.6.2 Hydrostatic pressure tests
A hydrostatic pressure test shall be carried out on the steam boiler before 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. Steam boiler surfaces have to withstand the test pressure without leaking or suffering permanent deformation.

The test pressure is generally required to be at least 1.5 times the maximum allowable working pressure, subject to a minimum of $p_{\text{perm}} + 1$ bar.

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. 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.

2.7 Hot water generators

2.7.1 Design
In respect of the materials used and the strength calculations, hot water generators heated by solid, liquid or gaseous fuels, by waste gases or by electrical means shall be treated in a manner analogous to that applied to steam generators. The materials and strength calculations for hot water generators which are heated solely by steam or hot liquids only are subject to the requirements in [1].

2.7.2 Equipment
The safety equipment of hot water generators is subject to the requirements contained in recognized standards accepted by the Society with due regard for the special conditions attaching to shipboard operation.

2.7.3 Testing
Each hot water generator is to be subjected to a constructional test and to a hydrostatic pressure test at least 1.5 times the maximum allowable working pressure, subject to a minimum of 4 bar.

3 Thermal oil heaters

3.1 General

3.1.1 Scope
The following requirements apply to the components in thermal oil systems in which organic liquids (thermal oils) are heated by oil burners or electricity to temperatures below their initial boiling point at atmospheric pressure.

Thermal oil heaters to which thermal energy is supplied by engine exhaust gases can also be approved. The safety equipment is subject, as applicable, to the Society's Rules.

3.1.2 Definitions
The "maximum allowable working pressure" is the maximum pressure which may occur in the individual parts of the equipment under service conditions.

The "thermal oil temperature" is the temperature of the thermal oil at the centre of the flow cross-section.

The "discharge temperature" is the temperature of the thermal oil immediately at the heater outlet.

The "return temperature" is the temperature of the thermal oil immediately at the heater inlet.
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.

**3.1.3 Documents for approval**
The following documents shall 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 vessel and other pressure vessels
— circuit diagrams of the electrical control system and monitoring and safety devices with limiting values respectively
— a functional diagram with information about the safety and monitoring devices and valves provided.

If specially requested, mathematical proof of the maximum film temperature in accordance with a recognized standard, accepted by the Society, shall be submitted.

**3.1.4 Construction and manufacture**
Design calculation, materials, manufacture and testing are governed by:

— [2] for heaters
— [1] for expansion and pressure vessels
— [4] for oil firing systems (the cut-out conditions for trips are as stated in [3.2.2] and [3.3.2])
— Ch.2 Sec.1 for pipes, pumps, valves and fittings

However, grey cast iron is not permitted for components of the hot thermal oil circuit.

Welded structures are subject to Pt.2.

**3.1.5 Thermal oils**
The thermal oil has to remain serviceable for at least 1 year at the specified thermal oil temperature. Its suitability for further use shall be verified at appropriate intervals, but at least once a year.

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.

Precautions shall be taken to protect the thermal oil from oxidation.

Copper and copper alloys, which due to their catalytic effect lead to an increased ageing of the thermal oil shall be avoided or oils with specific additives shall be used.

**3.1.6 Manual operation**
For thermal oil heaters which are operated automatically, means for operation and supervision shall be provided which allow a manual operation with the following minimum requirements by using an additional control level:

At least the temperature limiter on the oil side and the flow limiter shall remain operative at the oil-fired heater.

The safety equipment not required for manual operation may only be deactivated by means of a key-operated switch. The actuation of the key-operated switch shall be indicated.

For details of requirements in respect of the manual operation of the oil firing equipment, see [4].

Manual operation requires constant and direct supervision of the system.

**3.2 Heaters**

**3.2.1 Design**
The heater shall be equipped with an automatic, rapidly controllable heating system.
Heaters shall be designed thermodynamically and by construction in a way that neither the surfaces nor the thermal oil become excessively heated at any point. The flow of the thermal oil shall be ensured by forced circulation.

The surfaces which come into contact with the thermal oil shall be designed for the maximum allowable working pressure, subject to a minimum gauge pressure of 10 bar.

Oil-fired heaters shall be provided with inspection openings for the examination of the combustion chamber. Sensors for the temperature measuring and monitoring devices shall be introduced into the system through welded-in immersion pipes.

Heaters shall be fitted with devices enabling them to be completely drained.

### 3.2.2 Equipment and safety devices

Temperature-indicating devices shall be fitted at the discharge and return line as well as in the flue gas outlet of the heater.

The outlet of the circulating pump is to be equipped with a pressure gauge. The maximum allowable working pressure $P_B$ shall be indicated on the scale by a red mark which is permanently fixed and well visible. The indicating range has to include the test pressure.

For automatic control of the discharge temperature, oil-fired heaters shall be equipped with an automatic and rapidly adjustable heat supply in accordance with [4].

If the allowable discharge temperature is exceeded for oil-fired heaters, the oil burner shall be switched off and interlocked by a temperature limiter.

Parallel-connected heating surfaces shall be monitored individually at the discharge side of each coil. At the oil-fired heater, the oil burner shall be switched off and interlocked by a temperature limiter in case the allowable discharge temperature is exceeded in at least one coil. An additional supervision of the allowable discharge temperature of the heater is not necessary.

A flow monitor switched as a limiter shall be provided at the oil-fired heater. If the flow rate falls below a minimum value, the oil burner shall be switched off and interlocked.

### 3.2.3 Start-up of the oil burner shall be prevented by interlocks if the circulating pump is at standstill.

If the specified flue gas temperature is exceeded, the heating shall be switched off by a temperature limiter.

Electrical equipment items are subject to Ch.4 and Ch.5 Sec.1.

### 3.3 Pressure vessels

#### 3.3.1 All pressure vessels, including those open to the atmosphere, shall be designed for a pressure of at least 2 bar, unless provision shall be made for a higher working pressure

Air ducts shall be installed above the free deck and shall be fitted with automatic shut-off devices.

Drains shall be self-closing.

#### 3.3.2 Expansion vessel

An expansion vessel shall 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 shall be regarded as minimum requirements: 1.5 times the increase in volume for charges up to 1000 litres, and 1.3 times the increase for charges over 1000 litres. The volume is the total quantity of thermal oil contained in the system up to the lowest liquid level in the expansion vessel.

The expansion vessel shall be equipped with a liquid level gauge with a mark indicating the lowest allowable liquid level.

Level gauges made of glass, plexiglass or plastic are not allowed.

A limit switch is to be fitted which shuts down and interlocks the oil burner and switches off the circulating pumps if the liquid level falls below the allowable minimum.
Additionally, an alarm for low liquid level shall be installed, e.g. by means of an adjustable level switch on the level indicator, in order to give an early warning of a falling liquid level in the expansion vessel (e.g. in case of a leakage).

An alarm is also to be provided for the maximum liquid level.

The expansion vessel shall be provided with an overflow line leading to the drainage tank.

For rapid drainage in case of danger, a quick-opening valve shall be fitted directly to the expansion vessel with remote control from outside the space in which the equipment is installed.

The quick drainage line may be routed jointly with the overflow line to the drainage tank.

The opening of the quick drainage valve shall activate an alarm. At the same time, a non-safety related shut-down of the oil burner at the oil-fired heater should be carried out.

Where the expansion vessel is installed outside the engine room, the quick drainage valve may be replaced by an emergency shut-off device which, in the event of danger, prevents the egress of large quantities of thermal oil.

A safety expansion line shall connect the system to the expansion vessel. This shall be installed with a continuous positive gradient and shall be dimensioned in a way that a pressure increase of more than 10 above the maximum allowable working pressure in the system is avoided.

The dimensions of the expansion, overflow, drainage and venting pipes shall comply with Table 6.

All parts of the system in which thermal oil can expand due to the absorption of heat from outside shall be safeguarded against excessive pressure. Any thermal oil emitted shall be safely drained off.

### Table 6 Nominal diameter of expansion, overflow, drainage and venting pipes depending on the output of the heaters

<table>
<thead>
<tr>
<th>Total output of heaters [kW]</th>
<th>Expansion and overflow pipes - nominal diameter DN</th>
<th>Drainage and venting pipes - nominal diameter DN</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 600</td>
<td>25</td>
<td>32</td>
</tr>
<tr>
<td>≤ 900</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>≤ 1200</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>≤ 2400</td>
<td>50</td>
<td>65</td>
</tr>
<tr>
<td>≤ 6000</td>
<td>65</td>
<td>80</td>
</tr>
</tbody>
</table>

#### 3.3.3 Pre-pressurized systems

Pre-pressurized systems shall be equipped with an expansion vessel, which content is blanketed with an inert gas. The inert gas supply to the expansion vessel shall be guaranteed and monitored for minimum pressure. The pressure in the expansion vessel shall be indicated and safeguarded against overpressure.

A pressure limiter which gives an alarm and shuts down and interlocks the oil burner at a set-pressure below the set-pressure of the safety valve shall be provided at the expansion vessel.

#### 3.3.4 Drainage tanks

At the lowest point of the system, a drainage tank shall be located, the capacity of which is sufficient to hold the volume of the largest isolatable system section.

In exceptional cases, approval may be given for the drainage tank and the storage tank to be combined. Combined storage/drainage tanks shall be dimensioned in a way that in addition to the stock of thermal oil, there is volume for the content of the largest isolatable system section.

For air ducts and drains, see [3.3.1].

For sounding pipes, see Ch.2 Sec.1 [13].
3.4 Fire precautions
See Ch.7 Sec.1 [4.3].

3.5 Testing
After completion of installation on board, the system including the associated monitoring equipment shall be subjected to pressure, tightness and functional tests in the presence of the surveyor.

4 Oil burners and oil firing equipment

4.1 General

4.1.1 Scope
The following requirements apply to oil burners and oil firing equipment that shall be used for the burning of liquid fuels and installed in auxiliary steam boilers, thermal oil heaters and hot water generators, these being referred to as heat generators in the following.
The oil firing equipment of automatically controlled auxiliary steam boilers and thermal oil heaters is subject to the rules in [4.2].
The following general requirements of this subsection are mandatory for all installations and appliances.

4.1.2 Documents for approval
The following documents shall be submitted for approval.
— General drawings of the oil burner
— Piping and equipment diagram of the burner including parts list
— Description of function
— Electrical diagrams
— List of equipment regarding electrical control and safety.

4.1.3 Approved fuels
See Ch.1 Sec.1 [2.6].

4.1.4 Equipment of the heat generators and burner arrangement
Oil burners shall 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 shall be protected by refractory lining.
The firing system shall be so arranged as to prevent flames from blowing back into the boiler or engine room and to allow unburnt fuel to be safely drained.
Observation openings shall be provided at suitable points on the heat generator or burner through which the ignition flame, the main flame and the lining can be observed.
The functioning of explosion doors or rupture disks may not endanger personnel or important items of equipment in the boiler room.
Fuel leaking from potential leak points shall be safely collected in oiltight trays and to be drained away.

4.1.5 Simultaneous operation of oil burners and internal combustion machinery
The operation of oil burners 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.
4.2 Oil firing equipment for boilers and thermal oil heaters

4.2.1 Preheating of fuel oil
The equipment has to enable the heat generators to be started up with the facilities available on board. Where only steam-operated preheaters are present, fuel which does not require preheating shall be available to start up the boilers.
Any controllable heat source may be used to preheat the fuel oil. Preheating with open flame is not permitted.
The fuel oil supply temperature shall be selected so as to avoid excessive foaming, the formation of vapour or gas and also the formation of deposits on the heating surface.
Temperature or viscosity control shall be done automatically. For monitoring purposes, a thermometer or viscosimeter shall be fitted to the fuel oil pressure line in front of the burners. Should the oil temperature or viscosity deviate above or below the permitted limits, an alarm system has to signal this fact to the heat generator control panel.
When a change is made from heavy to light oil, the light oil shall not be passed through the heater or be excessively heated (alarm system).
The dimensional and constructional design of pressurized fuel oil preheaters is subject to the requirements set out in [1].
Electrically heated continuous-flow heaters shall be equipped with temperature safety trips in accordance with [1.5.3].

4.2.2 Pumps, pipelines, valves and fittings
Fuel oil service pumps may be connected only to the fuel system.
Pipelines shall be permanently installed and joined by oiltight welds, oiltight threaded connections of approved design or with flanged joints. Flexible hoses may be used only immediately in front of the burner or to enable the burner to swivel. They shall be installed with adequate bending radii and shall be protected against undue heating. For non-metallic flexible pipes and expansion compensators, see Ch.2 Sec.1 [14].
Suitable devices, e.g. relief valves, shall be fitted to prevent any excessive pressure increase in the fuel oil pump or pressurized fuel lines.
By means of a hand-operated, quick-closing device mounted at the fuel oil manifold, it shall be possible to isolate the fuel supply to the burners from the pressurized fuel lines. Depending on the design and method of operation, a quick-closing device may also be required directly in front of each burner.

4.2.3 Safety equipment
The correct sequence of safety functions when the burner is started up or shut down shall be ensured by means of a burner control box.
Two automatic quick-closing devices shall be provided at the fuel oil supply line to the burner.
For the fuel oil supply line to the ignition burner, one automatic quick-closing device will be sufficient, if the fuel oil pump is switched off after ignition of the burner.
The automatic quick-closing devices shall not release the oil supply to the burner during start-up and shall interrupt the oil supply during operation (automatic restart possible) if one of the following faults occurs:
— failure of the required pressure of the atomizing medium (steam and compressed-air atomizers)
  — failure of the oil pressure needed for atomization (pressure atomizers) or insufficient rotary speed of spinning cup or primary air pressure too low (rotary cup atomizers)
— failure of combustion air supply
— failure of control power supply
— failure of induced-draught fan or insufficient opening of exhaust gas register
— burner not in operating position.
The fuel oil supply shall be interrupted by closing the automatic quick-closing devices and interlocked by means of the burner control box if

— the flame does not develop within the safety period following start-up
— the flame is extinguished during operation and an attempt to restart the burner within the safety period is unsuccessful, or
— limit switches are actuated.

Every burner shall be equipped with a safety device for flame monitoring suitable for the particular fuel oil (spectral range of the burner flame is to be observed) in use. This appliance has to comply with the following safety periods on burner start-up or when the flame is extinguished in operation:

— on start-up 5 seconds
— in operation 1 second.

Where it is justified, longer safety periods may be permitted for 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 igniters (e.g. ignition burners).

“Safety period” is the maximum permitted time during which fuel oil may be supplied to the combustion space in the absence of a flame.

Oil 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 an emergency, it shall be possible to close the automatic quick-closing devices from the heat generator control platform and - where applicable - from the engine control room.

4.2.4 Design and construction of burners

The type and design of the burner and its atomizing and air turbulence equipment shall ensure virtually complete combustion.

Oil burners shall be so designed and constructed 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 drip water.

Oil burners are to be so constructed that they can be retracted or pivoted out of the operating position only when the fuel oil supply has been cut-off. The high-voltage ignition system shall be automatically disconnected when this occurs. A catch shall be provided to hold the burner in the swung out position.

Burners that can be retracted or pivoted shall be provided with a catch to hold the burner in the swung-out position.

Steam atomizers shall be fitted with appliances to prevent fuel oil entering the steam system.

Where dampers or similar devices are fitted in the air supply duct, care shall be taken to ensure that air for purging the combustion space is always available unless the oil supply is positively interrupted.

Every burner shall be equipped with an igniter. The ignition shall 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.

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.

Pivoted oil burners shall be so constructed that they can be swivelled out only after the fuel oil has been cut off. The high-voltage ignition equipment shall likewise be disconnected when this happens.

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.

4.2.5 Purging of combustion chamber and flues, exhaust gas ducting

The combustion chamber and flues shall be adequately purged with air prior to every burner start-up. A warning sign is to be mounted to this effect.

A threefold renewal of the total air volume of the combustion chamber and the flue gas duct 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.

Bends and dead corners in the exhaust gas ducting shall be avoided.

Dampers in uptakes and funnels should be avoided. Any dampers which may be fitted shall be so installed that no oil 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.

Where an induced-draught fan is fitted, an interlocking system shall prevent start-up of the burner equipment before the fan has started. A corresponding interlocking system shall also be provided for any covers which may be fitted to the funnel opening.

4.2.6 Electrical equipment
Electrical equipment and its degree of protection has to comply with the rules in Ch.8.
Safety appliances and flame monitors shall be self-monitoring and shall be connected in such a way as to prevent the supply of oil in the event of a break in the circuitry of the automatic oil burning system.

The equipment in the oil firing system shall be suitable for the use in oil firing systems and on ships. The proof of the suitability of the limiters and the alarm transmitters for e.g. burner control box, flame monitoring device and automatic quick-closing device shall be demonstrated by a type approval examination according to the requirements of the Society's rules.

High-voltage igniters shall be adequately protected against unauthorized interference.

4.2.7 Manual operation
For oil burners at heat generators that are operated automatically, means for operation and supervision shall be provided which allow a manual operation with the following minimum requirements by using an additional control level.

4.2.8 Flame monitoring shall remain active.

4.2.9 The safety equipment not required for manual operation may only be set out of function by means of a key-operated switch. The actuation of the key-operated switch shall be indicated.

4.2.10 Manual operation requires constant and direct supervision of the system.

4.2.11 Testing
Test at the manufacturer’s workshop
For burners of heat generators, the following examinations shall be performed at the manufacturer’s shop and documented by a Society approval certificate:

— visual inspection and completeness check
— pressure test of the oil preheater, if available and required according to this chapter
— pressure test of the burner
— insulation resistance test
— high voltage test
— functional test of the safety-related equipment.

Tests on board
After installation, a pressure and tightness test of the fuel system, including fittings, shall be performed.

The system, including the switchboard installed at the heat generator on board the vessel, shall be functionally tested as follows; in particular, the required purging time shall be identified and manual operation shall be demonstrated.

— completeness check for the required components of the equipment
— functional test of all safety-relevant equipment
— functional test of the burner control box
— identification of maximum and minimum burner power
— identification of flame stability on start-up, at maximum and at minimum burner power, under consideration of combustion chamber pressure (unspecified pressure changes are not permitted).
— proof regarding required purging of flues and safety times
— in case the oil burner is operated with different fuel oils, the proper change-over to another fuel oil quality and especially the safe operation of the flame monitoring, the quick-closing devices and the preheater, if existing, are to be checked
— proof regarding combustion properties, e.g. volumetric content of CO₂ (and possibly O₂ and CO) and soot number at minimum, mean and maximum power, in case of statutory requirements.

The correct combustion at all settings as well as the function of safety equipment shall be verified. A DNV GL approval Certificate of the oil burner regarding examination at the manufacturer’s shop shall be presented to the Society during functional testing.

Burners for warm water generators shall be delivered with a test protocol issued by the manufacturer.
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