5. Piping Design, Treatment and Installation

This chapter provides general guidelines for the design, construction and planning of piping systems, however, not excluding other solutions of at least equal standard. Installation related instructions are included in the project specific instructions delivered for each installation.

Fuel, lubricating oil, fresh water and compressed air piping is usually made in seamless carbon steel (DIN 2448) and seamless precision tubes in carbon or stainless steel (DIN 2391), exhaust gas piping in welded pipes of corten or carbon steel (DIN 2458). Sea-water piping should be in Cunifer or hot dip galvanized steel.

Gas piping between Gas Valve Unit and the engine is to be made of stainless steel.

**NOTE!** The pipes in the freshwater side of the cooling water system must not be galvanized!

Attention must be paid to fire risk aspects. Fuel supply and return lines shall be designed so that they can be fitted without tension. Flexible hoses must have an approval from the classification society. If flexible hoses are used in the compressed air system, a purge valve shall be fitted in front of the hose(s).

It is recommended to make a fitting order plan prior to construction.

The following aspects shall be taken into consideration:

- Pockets shall be avoided. When not possible, drain plugs and air vents shall be installed
- Leak fuel drain pipes shall have continuous slope
- Vent pipes shall be continuously rising
- Flanged connections shall be used, cutting ring joints for precision tubes
- Flanged connections shall be used in fuel oil, lubricating oil, compressed air and fresh water piping
- Welded connections (TIG) must be used in gas fuel piping as far as practicable, but flanged connections can be used where deemed necessary

Maintenance access and dismounting space of valves, coolers and other devices shall be taken into consideration. Flange connections and other joints shall be located so that dismounting of the equipment can be made with reasonable effort.

### 5.1 Pipe dimensions

When selecting the pipe dimensions, take into account:

- The pipe material and its resistance to corrosion/erosion.
- Allowed pressure loss in the circuit vs delivery head of the pump.
- Required net positive suction head (NPSH) for pumps (suction lines).
- In small pipe sizes the max acceptable velocity is usually somewhat lower than in large pipes of equal length.
- The flow velocity should not be below 1 m/s in sea water piping due to increased risk of fouling and pitting.
- In open circuits the velocity in the suction pipe is typically about 2/3 of the velocity in the delivery pipe.
### Table 5.1 Recommended maximum velocities on pump delivery side for guidance

<table>
<thead>
<tr>
<th>Piping</th>
<th>Pipe material</th>
<th>Max velocity [m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG piping</td>
<td>Stainless steel</td>
<td>3</td>
</tr>
<tr>
<td>Fuel gas piping</td>
<td>Stainless steel / Carbon steel</td>
<td>20</td>
</tr>
<tr>
<td>Fuel oil piping (MDF and HFO)</td>
<td>Black steel</td>
<td>1.0</td>
</tr>
<tr>
<td>Lubricating oil piping</td>
<td>Black steel</td>
<td>1.5</td>
</tr>
<tr>
<td>Fresh water piping</td>
<td>Black steel</td>
<td>2.5</td>
</tr>
<tr>
<td>Sea water piping</td>
<td>Galvanized steel</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Aluminum brass</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>10/90 copper-nickel-iron</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>70/30 copper-nickel</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>Rubber lined pipes</td>
<td>4.5</td>
</tr>
</tbody>
</table>

**NOTE!** The diameter of gas fuel piping depends only on the allowed pressure loss in the piping, which has to be calculated project specifically.

Compressed air pipe sizing has to be calculated project specifically. The pipe sizes may be chosen on the basis of air velocity or pressure drop. In each pipeline case it is advised to check the pipe sizes using both methods, to this ensure that the alternative limits are not being exceeded.

**Pipeline sizing on air velocity:** For dry air, practical experience shows that reasonable velocities are 25...30 m/s, but these should be regarded as the maximum above which noise and erosion will take place, particularly if air is not dry. Even these velocities can be high in terms of their effect on pressure drop. In longer supply lines, it is often necessary to restrict velocities to 15 m/s to limit the pressure drop.

**Pipeline sizing on pressure drop:** As a rule of thumb the pressure drop from the starting air vessel to the inlet of the engine should be max. 0.1 MPa (1 bar) when the bottle pressure is 3 MPa (30 bar).

It is essential that the instrument air pressure, feeding to some critical control instrumentation, is not allowed to fall below the nominal pressure stated in chapter "Compressed air system" due to pressure drop in the pipeline.

### 5.2 Trace heating

The following pipes shall be equipped with trace heating (steam, thermal oil or electrical). It shall be possible to shut off the trace heating.

- All heavy fuel pipes
- All leak fuel and filter flushing pipes carrying heavy fuel

### 5.3 Pressure class

The pressure class of the piping should be higher than or equal to the design pressure, which should be higher than or equal to the highest operating (working) pressure. The highest operating (working) pressure is equal to the setting of the safety valve in a system.

The pressure in the system can:

- Originate from a positive displacement pump
- Be a combination of the static pressure and the pressure on the highest point of the pump curve for a centrifugal pump
- Rise in an isolated system if the liquid is heated

Within this publication there are tables attached to drawings, which specify pressure classes of connections. The pressure class of a connection can be higher than the pressure class required for the pipe.

**Example 1:**

The fuel pressure before the engine should be 0.7 MPa (7 bar). The safety filter in dirty condition may cause a pressure loss of 0.1 MPa (1.0 bar). The viscosimeter, automatic filter, preheater and piping may cause a
pressure loss of 0.25 MPa (2.5 bar). Consequently the discharge pressure of the circulating pumps may rise to 1.05 MPa (10.5 bar), and the safety valve of the pump shall thus be adjusted e.g. to 1.2 MPa (12 bar).

- A design pressure of not less than 1.2 MPa (12 bar) has to be selected.
- The nearest pipe class to be selected is PN16.
- Piping test pressure is normally 1.5 x the design pressure = 1.8 MPa (18 bar).

**Example 2:**
The pressure on the suction side of the cooling water pump is 0.1 MPa (1 bar). The delivery head of the pump is 0.3 MPa (3 bar), leading to a discharge pressure of 0.4 MPa (4 bar). The highest point of the pump curve (at or near zero flow) is 0.1 MPa (1 bar) higher than the nominal point, and consequently the discharge pressure may rise to 0.5 MPa (5 bar) (with closed or throttled valves).

- Consequently a design pressure of not less than 0.5 MPa (5 bar) shall be selected.
- The nearest pipe class to be selected is PN6.
- Piping test pressure is normally 1.5 x the design pressure = 0.75 MPa (7.5 bar).

Standard pressure classes are PN4, PN6, PN10, PN16, PN25, PN40, etc.

### 5.4 Pipe class

Classification societies categorize piping systems in different classes (DNV) or groups (ABS) depending on pressure, temperature and media. The pipe class can determine:

- Type of connections to be used
- Heat treatment
- Welding procedure
- Test method

Systems with high design pressures and temperatures and hazardous media belong to class I (or group I), others to II or III as applicable. Quality requirements are highest on class I.

Examples of classes of piping systems as per DNV rules are presented in the table below.

Gas piping is to be designed and manufactured and documented according to the rules of the relevant classification society.

In the absence of specific rules or if less stringent than those of DNV the application of DNV rules is recommended.

**Relevant DNV rules:**
- Ship Rules Part 4 Chapter 6, Piping Systems
- Ship Rules Part 5 Chapter 5, Liquefied Gas Carriers
- Ship Rules Part 6 Chapter 13, Gas Fuelled Engine Installations

**Table 5.2 Classes of piping systems as per DNV rules**

<table>
<thead>
<tr>
<th>Media</th>
<th>Class I</th>
<th></th>
<th>Class II</th>
<th></th>
<th>Class III</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MPa (bar)</td>
<td>°C</td>
<td>MPa (bar)</td>
<td>°C</td>
<td>MPa (bar)</td>
<td>°C</td>
</tr>
<tr>
<td>Steam</td>
<td>&gt; 1.6 (16)</td>
<td>or &gt; 300</td>
<td>&lt; 1.6 (16)</td>
<td>and &lt; 300</td>
<td>&lt; 0.7 (7)</td>
<td>and &lt; 170</td>
</tr>
<tr>
<td>Flammable fluid</td>
<td>&gt; 1.6 (16)</td>
<td>or &gt; 150</td>
<td>&lt; 1.6 (16)</td>
<td>and &lt; 150</td>
<td>&lt; 0.7 (7)</td>
<td>and &lt; 60</td>
</tr>
<tr>
<td>Fuel gas</td>
<td>All</td>
<td>All</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other media</td>
<td>&gt; 4 (40)</td>
<td>or &gt; 300</td>
<td>&lt; 4 (40)</td>
<td>and &lt; 300</td>
<td>&lt; 1.6 (16)</td>
<td>and &lt; 200</td>
</tr>
</tbody>
</table>

### 5.5 Insulation

The following pipes shall be insulated:

- All trace heated pipes
• Exhaust gas pipes
• Exposed parts of pipes with temperature > 60°C

Insulation is also recommended for:
• Pipes between engine or system oil tank and lubricating oil separator
• Pipes between engine and jacket water preheater

5.6 Local gauges

Local thermometers should be installed wherever a new temperature occurs, i.e. before and after heat exchangers, etc.
Pressure gauges should be installed on the suction and discharge side of each pump.

5.7 Cleaning procedures

Instructions shall be given at an early stage to manufacturers and fitters how different piping systems shall be treated, cleaned and protected.

5.7.1 Cleanliness during pipe installation

All piping must be verified to be clean before lifting it onboard for installation. During the construction time uncompleted piping systems shall be maintained clean. Open pipe ends should be temporarily closed. Possible debris shall be removed with a suitable method. All tanks must be inspected and found clean before filling up with fuel, oil or water.

Piping cleaning methods are summarised in table below:

<table>
<thead>
<tr>
<th>System</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel gas</td>
<td>A,B,C</td>
</tr>
<tr>
<td></td>
<td>D,F 1)</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>A,B,C,D,F</td>
</tr>
<tr>
<td>Lubricating oil</td>
<td>A,B,C,D,F</td>
</tr>
<tr>
<td>Starting air</td>
<td>A,B,C</td>
</tr>
<tr>
<td>Cooling water</td>
<td>A,B,C</td>
</tr>
<tr>
<td>Exhaust gas</td>
<td>A,B,C</td>
</tr>
<tr>
<td>Charge air</td>
<td>A,B,C</td>
</tr>
</tbody>
</table>

1) In case of carbon steel pipes

Methods applied during prefabrication of pipe spools

A = Washing with alkaline solution in hot water at 80°C for degreasing (only if pipes have been greased)
B = Removal of rust and scale with steel brush (not required for seamless precision tubes)
D = Pickling (not required for seamless precision tubes)

Methods applied after installation onboard

C = Purging with compressed air
F = Flushing

5.7.2 Pickling

Prefabricated pipe spools are pickled before installation onboard.
Pipes are pickled in an acid solution of 10% hydrochloric acid and 10% formaline inhibitor for 4-5 hours, rinsed with hot water and blown dry with compressed air.
After acid treatment the pipes are treated with a neutralizing solution of 10% caustic soda and 50 grams of trisodiumphosphate per litre of water for 20 minutes at 40...50°C, rinsed with hot water and blown dry with compressed air.
Great cleanliness shall be approved in all work phases after completed pickling.

5.8 **Flexible pipe connections**

Pressurized flexible connections carrying flammable fluids or compressed air have to be type approved. Great care must be taken to ensure proper installation of flexible pipe connections between resiliently mounted engines and ship’s piping.

- Flexible pipe connections must not be twisted
- Installation length of flexible pipe connections must be correct
- Minimum bending radius must respected
- Piping must be concentrically aligned
- When specified the flow direction must be observed
- Mating flanges shall be clean from rust, burrs and anticorrosion coatings
- Bolts are to be tightened crosswise in several stages
- Flexible elements must not be painted
- Rubber bellows must be kept clean from oil and fuel
- The piping must be rigidly supported close to the flexible piping connections.

*Figure 5.1 Flexible hoses*
5.9 Clamping of pipes

It is very important to fix the pipes to rigid structures next to flexible pipe connections in order to prevent damage caused by vibration. The following guidelines should be applied:

- Pipe clamps and supports next to the engine must be very rigid and welded to the steel structure of the foundation.
- The first support should be located as close as possible to the flexible connection. Next support should be 0.3-0.5 m from the first support.
- First three supports closest to the engine or generating set should be fixed supports. Where necessary, sliding supports can be used after these three fixed supports to allow thermal expansion of the pipe.
- Supports should never be welded directly to the pipe. Either pipe clamps or flange supports should be used for flexible connection.

Examples of flange support structures are shown in Figure 5.2. A typical pipe clamp for a fixed support is shown in Figure 5.3. Pipe clamps must be made of steel; plastic clamps or similar may not be used.

**Figure 5.2** Flange supports of flexible pipe connections (4V60L0796)
### Figure 5.3 Pipe clamp for fixed support (4V61H0842)

<table>
<thead>
<tr>
<th>DN</th>
<th>d_o [mm]</th>
<th>D [mm]</th>
<th>a [mm]</th>
<th>b [mm]</th>
<th>c [mm]</th>
<th>d [mm]</th>
<th>BOLTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>33.7</td>
<td>35</td>
<td>150</td>
<td>80</td>
<td>120</td>
<td>25</td>
<td>M10×50</td>
</tr>
<tr>
<td>32</td>
<td>42.4</td>
<td>43</td>
<td>160</td>
<td>75</td>
<td>120</td>
<td>25</td>
<td>M10×50</td>
</tr>
<tr>
<td>40</td>
<td>48.3</td>
<td>48</td>
<td>154.5</td>
<td>100</td>
<td>115</td>
<td>25</td>
<td>M12×60</td>
</tr>
<tr>
<td>50</td>
<td>60.3</td>
<td>61</td>
<td>185</td>
<td>100</td>
<td>145</td>
<td>25</td>
<td>M12×60</td>
</tr>
<tr>
<td>65</td>
<td>76.1</td>
<td>76.5</td>
<td>191</td>
<td>115</td>
<td>145</td>
<td>25</td>
<td>M12×70</td>
</tr>
<tr>
<td>80</td>
<td>88.9</td>
<td>90</td>
<td>220</td>
<td>140</td>
<td>150</td>
<td>30</td>
<td>M12×90</td>
</tr>
<tr>
<td>100</td>
<td>114.3</td>
<td>114.5</td>
<td>196</td>
<td>170</td>
<td>121</td>
<td>25</td>
<td>M12×100</td>
</tr>
<tr>
<td>125</td>
<td>139.7</td>
<td>140</td>
<td>217</td>
<td>200</td>
<td>132</td>
<td>30</td>
<td>M16×120</td>
</tr>
<tr>
<td>150</td>
<td>168.3</td>
<td>170</td>
<td>237</td>
<td>240</td>
<td>132</td>
<td>30</td>
<td>M16×140</td>
</tr>
<tr>
<td>200</td>
<td>219.1</td>
<td>220</td>
<td>295</td>
<td>290</td>
<td>160</td>
<td>30</td>
<td>M16×160</td>
</tr>
<tr>
<td>250</td>
<td>273.0</td>
<td>274</td>
<td>355</td>
<td>350</td>
<td>190</td>
<td>30</td>
<td>M16×200</td>
</tr>
</tbody>
</table>

\[d_o = \text{Pipe outer diameter}\]