Marine and machinery systems and equipment
FOREWORD

DNV GL offshore standards contain technical requirements, principles and acceptance criteria related to classification of offshore units.

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Any comments may be sent by e-mail to rules@dnvgl.com

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CHANGES – CURRENT

Changes in this document are highlighted in red colour. However, if the changes involve a whole chapter, section or sub-section, normally only the title will be in red colour.

Changes January 2018, entering into force 1 July 2018

<table>
<thead>
<tr>
<th>Topic</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alignment with RU-SHIP</strong></td>
<td>Ch.2 Sec.1</td>
<td>Alignment with DNVGL-RU-SHIP.</td>
</tr>
<tr>
<td></td>
<td>Ch.2 Sec.2 [3.5] to Ch.2 Sec.2 [3.7]</td>
<td>Clarifying requirements for piping stress and flexibility analysis.</td>
</tr>
<tr>
<td></td>
<td>Ch.2 Sec.2</td>
<td>Alignment with DNVGL-RU-SHIP.</td>
</tr>
<tr>
<td></td>
<td>Ch.2 Sec.3</td>
<td>Alignment with DNVGL-RU-SHIP.</td>
</tr>
<tr>
<td></td>
<td>Ch.2 Sec.4 [13]</td>
<td>Added references to DNVGL-RU-SHIP on pollution prevention requirements.</td>
</tr>
<tr>
<td></td>
<td>Ch.2 Sec.5</td>
<td>Alignment with DNVGL-RU-SHIP.</td>
</tr>
<tr>
<td></td>
<td>Ch.2 Sec.6</td>
<td>Alignment with DNVGL-RU-SHIP.</td>
</tr>
<tr>
<td></td>
<td>Ch.3 Sec.2</td>
<td>Definition of compliance document types and consequent presentation of certification requirements aligned with DNVGL-RU-SHIP and DNVGL-RU-OU.</td>
</tr>
</tbody>
</table>

**Deleted references to ES notation**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ch.1 Sec.1 [1.4.5]</td>
<td>Deleted former clause describing ES notation.</td>
</tr>
<tr>
<td>Former Ch.2 Sec.1 [1.11]</td>
<td>Deleted clause.</td>
</tr>
<tr>
<td>Ch.3 Sec.1 [1.2]</td>
<td>Deleted clauses and former Table 2 referring to the ES notation.</td>
</tr>
</tbody>
</table>

**Updates based on experience feedback and technical developments**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
</table>
| Ch.1 Sec.1 | A general update of the introduction section including:
- The scope of the standard has been clarified.
- ES notation has been deleted.
- Structure of standard has been clarified.
Table 9 Symbols deleted. Same content is reflected in Ch.2 Sec.2 [3.4]. |
| Ch.2 Sec.1 [1.8.2] | Added guidance note on ship side penetrations. |
| Ch.2 Sec.1 [2.2.3] | Added reference to DNVGL-OS-D201. |
| Ch.2 Sec.3 [3.1.2] and Ch.2 Sec.3 [3.4.2] | Added guidance notes supporting the understanding of rule requirements for TLP’s. |
| Ch.2 Sec.3 [1.1] | Reference to DNVGL-RU-SHIP has been changed to be valid for this section only. |
| Ch.2 Sec.4 [1.1] | Reference to DNVGL-RU-SHIP has been changed to be valid for this section only. |
| Ch.3 Sec.3 [2.4.4] | In the second paragraph the wording has been changed from “...highest specified design lifting load…” to “...maximum elevated weight and maximum pre-load”.

Editorial corrections

In addition to the above stated changes, editorial corrections may have been made.
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5. Abbreviations
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3. Personnel protection

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5. Valves
6. Flexible hoses
7. Detachable pipe connections
8. Socket welded joints and slip-on sleeve welded joints

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3. Ballast and bilge systems for column-stabilised units and installations
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CHAPTER 1 GENERAL

SECTION 1 INTRODUCTION

1 General

1.1 Introduction
This offshore standard provides principles, technical requirements and guidance for design, manufacturing and installation of marine and machinery systems and equipment for mobile units and floating offshore installations.

1.2 Objective
The objectives of this standard are to:
— provide an internationally acceptable standard of safety by defining minimum requirements for offshore marine and machinery systems and equipment
— serve as a contractual reference document between suppliers and purchasers
— serve as a guideline for designers, suppliers, purchasers and regulators
— specify procedures and requirements for units or installations subject to DNV GL certification and classification.

1.3 Scope

1.3.1 The requirement in this standard cover marine (platform) piping systems, machinery piping systems and marine machinery systems, which are defined as systems serving the marine systems on an offshore unit or installation and not primarily intended for operation in drilling or hydrocarbon production service or dedicated auxiliary systems. Interfaces between such systems and marine systems should be identified and a specification break defined.

Guidance note:
Piping and equipment for drilling and drilling related auxiliary systems are addressed in DNVGL-OS-E101.
Piping and equipment for hydrocarbon production and production related auxiliary systems are addressed in DNVGL-OS-E201.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.3.2

1.3.3 Piping and equipment in connection with LNG storage are addressed in DNVGL-RU-SHIP Pt.5 Ch.7.

1.3.4 Hydrocarbon loading/offloading systems are addressed in DNVGL-OS-E201.

1.4 Application

1.4.1 The requirements of this standard are applicable for mobile units and floating offshore installations of the ship-shaped, self-elevating and column-stabilised design types, but may also be applied to other types of floating constructions, as applicable.

1.4.2 The requirements of this standard may also be applied to equivalent areas of fixed offshore installations.
1.4.3 Piping and equipment in connection with hydrocarbon storage (including product piping, inert gas system, gas freeing and venting system and crude oil washing system) are addressed in the DNVGL-RU-SHIP Pt.5 Ch.5. The additional requirements to class III piping in this standard shall be applied.

1.4.4 Reference to DNVGL-RU-SHIP Pt.5 Ch.5 is conditioned that there is no coinciding production and tank inspection. For units subject to in-service inspection of the cargo system during production, additional requirements are given in DNVGL-OS-A101 Ch.2 Sec.7 or DNVGL-OS-A101 Ch.2 Sec.8 as applicable.

Guidance note:
Some systems used for typical tank ship applications, (e.g. cargo piping, ballast systems, firewater systems), should be especially considered, for example with respect to fabrication quality and support arrangement, when evaluated for use on offshore installations in view of differing operational conditions and overall safety and maintenance philosophy.

1.4.5 Interpretations
This standard has been based on internationally accepted principal requirements, defined in the normative references as listed in [2]. In cases where these a) contain only functional requirements, b) allow alternative solutions to prescriptive requirements or c) are generally or vaguely worded, a DNVGL interpretation has been added.

1.4.6 The interpretations are not aiming at introducing additional requirements but at achieving uniform application of the principal requirements. The interpretations can be regarded as norms for fulfilling the principle requirements.

1.4.7 The interpretations do not preclude the use of other alternative solutions. Such solutions shall be documented and approved for compliance to the principal requirement equivalent to the original interpretation.

1.4.8 Classification
For use of this standard as technical basis for offshore classification as well as description of principles, procedures, and applicable class notations related to classification services, see Ch.3.

1.4.9 Governing regulations
Alternative designs and arrangements deviating from the different regulatory standards as adapted in this standard (e.g. MODU code requirements) may be specially considered.
For use of this standard to document compliance to the MODU code certificate, these deviations require acceptance of the flag administration.

1.4.10 The requirements of this standard are in compliance with relevant parts of the IMO MODU Code 2009. Note that for compliance with statutory requirements, later amendments may be applicable.

1.4.11 The standard has been written for general world-wide application. Governmental regulations may include requirements in excess of the provisions by this standard depending on the size, type, location and intended service of the offshore unit or installation.

1.5 Structure
This standard is divided into three chapters:
— Ch.1 General introduction, scope, definitions and references
2 Normative references

2.1 General

2.1.1 The following standards include provisions which, through reference in the text constitute provisions of this offshore standard. The latest issue of the references shall be used unless otherwise agreed.

2.1.2 Other recognised standards may be used provided it can be demonstrated that these meet or exceed the requirements of the standards referenced below.

2.1.3 Any deviations, exceptions and modifications to the design codes and standards shall be documented and agreed between the supplier, purchaser and verifier, as applicable.

2.2 Reference documents

2.2.1 Applicable DNVGL publications are given in Table 1.

Table 1 DNVGL reference documents

<table>
<thead>
<tr>
<th>Document code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNVG-OS-A101</td>
<td>Safety principles and arrangement</td>
</tr>
<tr>
<td>DNVGL-OS-B101</td>
<td>Metallic materials</td>
</tr>
<tr>
<td>DNVGL-OS-C102</td>
<td>Structural design of offshore ships</td>
</tr>
<tr>
<td>DNVGL-OS-C103</td>
<td>Structural design of column stabilised units (LRFD method)</td>
</tr>
<tr>
<td>DNVGL-OS-C104</td>
<td>Structural design of self-elevating units (LRFD method)</td>
</tr>
<tr>
<td>DNVGL-OS-C105</td>
<td>Structural design of TLPs (LRFD method)</td>
</tr>
<tr>
<td>DNVGL-OS-C106</td>
<td>Structural design of deep draught floating units/spars (LRFD and WSD method)</td>
</tr>
<tr>
<td>DNVGL-OS-C301</td>
<td>Stability and watertight integrity</td>
</tr>
<tr>
<td>DNVGL-OS-C401</td>
<td>Fabrication and testing of offshore structures</td>
</tr>
<tr>
<td>DNVGL-OS-D201</td>
<td>Electrical installations</td>
</tr>
<tr>
<td>DNVGL-OS-D202</td>
<td>Automation, safety, and telecommunication systems</td>
</tr>
<tr>
<td>DNVGL-OS-D301</td>
<td>Fire safety</td>
</tr>
<tr>
<td>DNVGL-OS-E301</td>
<td>Position mooring</td>
</tr>
<tr>
<td>DNVGL-RU-SHIP</td>
<td>Rules for classification of Ships</td>
</tr>
<tr>
<td>DNVGL-CG-0036</td>
<td>Calculation of gear rating for marine transmissions</td>
</tr>
<tr>
<td>DNVGL-CG-0194</td>
<td>Hydraulic cylinders</td>
</tr>
</tbody>
</table>
2.2.2 Other reference documents are given in Table 2.

Table 2 Normative references

<table>
<thead>
<tr>
<th>Document code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASME IX</td>
<td>ASME Boiler and Pressure Vessel Code (BPVC), Section IX: Welding, Brazing, and Fusing Qualifications</td>
</tr>
<tr>
<td>EN 10204</td>
<td>Metallic products - Types of inspection documents</td>
</tr>
<tr>
<td>ICLL</td>
<td>International Convention on Load Lines, 1966 as amended</td>
</tr>
<tr>
<td>IMO MODU Code</td>
<td>Code for the Construction and Equipment of Mobile Offshore Drilling Units (2009)</td>
</tr>
<tr>
<td>ISO 281</td>
<td>Rolling bearings - Dynamic load ratings and rating life</td>
</tr>
<tr>
<td>ISO 898</td>
<td>Mechanical Properties of Fasteners</td>
</tr>
<tr>
<td>ISO 8861</td>
<td>Engine-room ventilation in diesel-engined ships</td>
</tr>
<tr>
<td>ISO 10474</td>
<td>Steel and steel products - Inspection documents</td>
</tr>
<tr>
<td>ISO 5817</td>
<td>Arc-welded joints in steel - Guidance on quality levels for imperfections</td>
</tr>
<tr>
<td>MARPOL 73/78</td>
<td>International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 as amended</td>
</tr>
</tbody>
</table>

3 Informative references

3.1 General

3.1.1 Informative references are not considered mandatory in the application of the offshore standard, but may be applied or used for background information.

3.1.2 Informative references are given in Table 3.

Table 3 Informative references

<table>
<thead>
<tr>
<th>Document code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASME B31.3</td>
<td>Process piping</td>
</tr>
</tbody>
</table>
### Document code

<table>
<thead>
<tr>
<th>Document code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D3806</td>
<td>Standard Test Method of Small-Scale Evaluation of Fire-Retardant Paints (2-Foot Tunnel Method)</td>
</tr>
<tr>
<td>DNVGL-RU-SHIP Pt.1 Ch.3 Sec.3</td>
<td>Plan approval documentation types – Definitions</td>
</tr>
<tr>
<td>DNVGL-OS-E101</td>
<td>Drilling plant</td>
</tr>
<tr>
<td>DNVGL-OS-E201</td>
<td>Hydrocarbon production plant</td>
</tr>
<tr>
<td>DNVGL-ST-0377</td>
<td>Standard for shipboard lifting appliances</td>
</tr>
<tr>
<td>DNVGL-ST-0378</td>
<td>Standard for offshore and platform lifting appliances</td>
</tr>
<tr>
<td>ENV 12097</td>
<td>Ventilation for buildings - Ductwork - Requirements for ductwork components to facilitate maintenance of ductwork systems</td>
</tr>
<tr>
<td>IMO Resolution A.653(16)</td>
<td>Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling and Deck Finish Materials</td>
</tr>
<tr>
<td>IMO Resolution A.753(18)</td>
<td>Guidelines for the Application of Plastic Pipes on Ships</td>
</tr>
<tr>
<td>ISO 75</td>
<td>Plastics - Determination of temperature of deflection under load</td>
</tr>
<tr>
<td>ISO 1127</td>
<td>Stainless steel tubes - Dimensions, tolerances and conventional masses per unit length</td>
</tr>
<tr>
<td>ISO 1461</td>
<td>Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods</td>
</tr>
<tr>
<td>ISO 12239</td>
<td>Fire Protection Equipment - Self Contained Smoke Alarms</td>
</tr>
<tr>
<td>UKOOA</td>
<td>United Kingdom Offshore Operators Association, Specification and Recommended Practice for use of GRP piping offshore</td>
</tr>
<tr>
<td>USCG PFM 1-98</td>
<td>US Coast Guard, Policy File Memorandum on the Fire Performance Requirements for Plastic Pipe per IMO Resolution A.753(18).</td>
</tr>
<tr>
<td>AWS D10.10</td>
<td>Recommended Practice for Local Heating of Welds in Piping and Tubing</td>
</tr>
</tbody>
</table>

### 4 Definitions

#### 4.1 Verbal forms

**Table 4 Verbal forms**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>shall</td>
<td>verbal form used to indicate requirements strictly to be followed in order to conform to the document</td>
</tr>
<tr>
<td>should</td>
<td>verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required</td>
</tr>
<tr>
<td>may</td>
<td>verbal form used to indicate a course of action permissible within the limits of the document</td>
</tr>
</tbody>
</table>
### 4.2 Definitions

#### Table 5 Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>column-stabilised unit</td>
<td>a unit with the main deck connected to the underwater hull or footings by columns or caissons</td>
</tr>
</tbody>
</table>
| engine room                               | this is the space containing propulsion machinery and machinery for generation of electrical power  
                                          | Rooms within or adjacent to the engine room with visual contact with the machinery are considered to be part of the engine room.           |
| floating offshore installation            | a buoyant construction engaged in offshore operations including drilling, production, storage or support functions, and which is designed and built for installation at a particular offshore location. |
| machinery spaces                          | all machinery spaces of category A and all other spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces  
                                          | (See MODU Code 1.3.33)                                                                                                                  |
| machinery spaces of category A           | those spaces and trunks to such spaces which contain:  
                                          | — internal combustion machinery used for main propulsion, or  
                                          | — internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or  
                                          | — any oil-fired boiler or oil fuel unit.  
                                          | (See MODU Code 1.3.34)                                                                                                                  |
| marine piping                             | piping serving the marine systems on an offshore unit and which is not primarily intended for operation in drilling or hydrocarbon production service or dedicated auxiliary systems |
| mobile unit                               | a buoyant construction engaged in offshore operations including drilling, production, storage or support functions, not intended for service at one particular offshore site and which can be relocated without major dismantling or modification |
| offshore installation                     | a buoyant or non-buoyant construction engaged in offshore operations including drilling, production, storage or support functions, and which is designed and intended for use at a location for an extended period |
| pipe tunnel                               | a space that can be entered via doors or hatches and shall be ventilated                                                                |
| piping                                    | Piping is defined to include the following components:  
                                          | — pipes  
                                          | — flanges with gaskets and bolts and other pipe connections  
                                          | — expansion elements  
                                          | — valves (including hydraulic and pneumatic actuators) and fittings  
                                          | — hangers and supports  
                                          | — flexible hoses  
<pre><code>                                      | — pump housings.                                                                                                                           |
</code></pre>
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>piping system</td>
<td>A piping system is defined to include piping, as well as components in direct connection to the piping such as pumps, heat exchangers, evaporators, independent tanks etc. with the exception of main components such as steam and gas turbines, diesel engines, reduction gears and boilers.</td>
</tr>
<tr>
<td>redundancy</td>
<td>The ability to maintain or restore a function when one failure has occurred. Redundancy can be achieved for instance by installation of more than one unit (component redundancy) or by having two or more separate systems capable of performing the same function (system redundancy).</td>
</tr>
<tr>
<td>system availability</td>
<td>The time the system is available</td>
</tr>
<tr>
<td>Continuous availability (R0)</td>
<td>None</td>
</tr>
<tr>
<td>High availability (R1)</td>
<td>30 seconds</td>
</tr>
<tr>
<td>Manual system restoration (R2)</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Repairable systems (R3)</td>
<td>3 hours</td>
</tr>
</tbody>
</table>

For more detailed definitions see DNVGL-OS-D202 Ch.2 Sec.1 [2].

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>acrylonitrile butadiene styrene</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>BS</td>
<td>British Standard (issued by British Standard Institution)</td>
</tr>
<tr>
<td>CG</td>
<td>DNV GL class guidelines</td>
</tr>
<tr>
<td>DIN</td>
<td>Deutsches Institut für Normung e.V.</td>
</tr>
<tr>
<td>EN</td>
<td>European norm</td>
</tr>
<tr>
<td>GMAW</td>
<td>gas metal arc welding</td>
</tr>
<tr>
<td>GRE</td>
<td>glass fibre reinforced epoxy</td>
</tr>
<tr>
<td>GRP</td>
<td>glass fibre reinforced polyester</td>
</tr>
<tr>
<td>GTAW</td>
<td>gas tungsten arc welding</td>
</tr>
</tbody>
</table>

5 Abbreviations
Abbreviations used are given in Table 6.

Table 6 Abbreviations

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>acrylonitrile butadiene styrene</td>
</tr>
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<td>ANSI</td>
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<tr>
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<td>American Petroleum Institute</td>
</tr>
<tr>
<td>ASME</td>
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</tr>
<tr>
<td>BS</td>
<td>British Standard (issued by British Standard Institution)</td>
</tr>
<tr>
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</tr>
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<tr>
<td>EN</td>
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</tr>
<tr>
<td>GMAW</td>
<td>gas metal arc welding</td>
</tr>
<tr>
<td>GRE</td>
<td>glass fibre reinforced epoxy</td>
</tr>
<tr>
<td>GRP</td>
<td>glass fibre reinforced polyester</td>
</tr>
<tr>
<td>GTAW</td>
<td>gas tungsten arc welding</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>HVAC</td>
<td>heating, ventilation and air conditioning</td>
</tr>
<tr>
<td>ICLL</td>
<td>International Convention on Load Lines</td>
</tr>
<tr>
<td>IMO</td>
<td>International Maritime Organization</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>LEL</td>
<td>lower explosion limit</td>
</tr>
<tr>
<td>LNG</td>
<td>liquefied natural gas</td>
</tr>
<tr>
<td>MPI</td>
<td>magnetic particle inspection</td>
</tr>
<tr>
<td>MT</td>
<td>magnetic particle testing</td>
</tr>
<tr>
<td>NDT</td>
<td>non-destructive testing</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association</td>
</tr>
<tr>
<td>OS</td>
<td>DNV GL offshore standard</td>
</tr>
<tr>
<td>PT</td>
<td>dye-penetrant testing</td>
</tr>
<tr>
<td>PWHT</td>
<td>post weld heat treatment</td>
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<tr>
<td>RP</td>
<td>DNV GL recommended practice</td>
</tr>
<tr>
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<td>radiographic testing</td>
</tr>
<tr>
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<td>Sheet Metal and Air Conditioning Contractors National Association</td>
</tr>
<tr>
<td>ST</td>
<td>DNV GL Standards</td>
</tr>
<tr>
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<td>test report</td>
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<tr>
<td>UKOOA</td>
<td>United Kingdom Offshore Operators Association</td>
</tr>
<tr>
<td>USCG</td>
<td>U.S. Coast Guard</td>
</tr>
<tr>
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<td>ultrasonic testing</td>
</tr>
<tr>
<td>WPQT</td>
<td>welding procedure qualification test</td>
</tr>
<tr>
<td>WPS</td>
<td>welding procedure specification</td>
</tr>
<tr>
<td>WPT</td>
<td>welding production test</td>
</tr>
</tbody>
</table>

6 Documentation

For documentation requirements related to certification and classification, see Ch.3.
CHAPTER 2 TECHNICAL PROVISIONS

SECTION 1 DESIGN PRINCIPLES

1 Arrangement

1.1 General

1.1.1 All machinery, systems and components that shall be operated or subject to inspection shall be installed and arranged for easy access.

1.1.2 All components in a system shall be satisfactorily matched with regard to function, capacity and strength. Relative motions between parts of the machinery shall be allowed for without inducing detrimental stresses.

1.1.3 All machinery shall be equipped with control and instrumentation considered necessary for safe operation of the machinery.

1.1.4 All spaces in which machinery is operated and where flammable or toxic gases or vapours may accumulate, or where a low oxygen atmosphere may occur, shall be provided with adequate ventilation under all conditions.

Guidance note:
By adequate ventilation is meant natural or mechanical ventilation sufficient to prevent an accumulation of gases above a concentration of 25% of their lower explosion limit (LEL).

1.1.5 The capacity and arrangement of machinery spaces and emergency generator room ventilation shall cover demands for operating the machinery, boilers and emergency generator at full power in all weather conditions.

On floating installations, ventilation inlets and outlets shall be located not less than 4.5 m above freeboard deck. Supply of air to the engine room/main power generation room, emergency power room and fire pump room shall be ensured even in the event of failure of one ventilation fan. As an alternative to the redundancy requirements in [2.3] alternative provision of air by adequate openings will be specially considered.

The air inlets and air outlets on open deck shall be positioned such as to avoid the ingress of exhaust air through the inlet openings into machinery space (short circuiting of air).

Guidance note:
Necessary capacity of ventilation may be calculated according to ISO Standard 8861.

1.1.6 Service and utility systems (e.g. steam, heating medium, cooling medium, compressed air, drains etc.) connected to systems containing flammable or toxic liquids or gases shall normally not be combined with similar systems located in non-hazardous areas or connected to non-hazardous systems.

1.1.7 Any connection between hazardous and non-hazardous systems shall be designed to eliminate or control the risk of ingress of hazardous material from one system to the other due to incorrect operation or leaks.

The following issues shall be evaluated by the designer and documented before systems are interconnected:
— identify possible failure modes and define a realistic range of leak sizes
— evaluate possible consequences of cross contamination
— describe and evaluate reliability, maintainability and testability of active and passive protection systems
  (e.g. liquid seals, non return valves, detectors, actuated valves, primary and secondary loops etc.).

If the potential consequences of cross contamination are found to be significant or the reliability of protective
measures is difficult to maintain or verify, separated systems shall be specified.

Guidance note:
Investigations following incidents have shown that gas can migrate backwards against the flow of liquids and past check valves.
Check valves alone are not normally regarded as reliable devices for prevention of cross contamination where gas is present.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.2 Prevention of inadvertent operations
The machinery and piping systems shall be so arranged that inadvertent operation, caused by human error,
cannot lead to the reduced safety of the unit, installation or personnel, or cause environmental damage.
This includes the following:
1) Open or closed position of valves shall be easily visible.
2) If a valve’s function in the system is not evident, there shall be adequate information on a name plate
   attached to the valve.
3) All connections to sea shall be marked: SEA DIRECT.
4) The machinery and piping systems shall be arranged to prevent sea water, cargo or ballast from reaching
dry spaces of the unit/installation or cargo (oils or chemicals) from being discharged overboard as a
consequence of inadvertent operations.
5) Systems and tanks shall be so arranged that leakage or any operation of valves will not directly lead to
increased risk of damage to machinery, ship or personnel due to mixing of different fluids.

1.3 Communications

1.3.1 For self-propelled units, at least two independent means shall be provided for communicating orders
from the navigating bridge to the position in the machinery space or the control room from which the engines
are normally controlled.
One of these shall provide visual indication of the orders and responses both in the engine-room and on the
navigating bridge.
(See MODU Code 7.7)

1.3.2 For self-propelled units, at least one means of communication shall be provided between the control
station or bridge and any other control position(s) from which the propulsion machinery may be controlled.
(See MODU Code 7.7)

1.4 Engineers’ alarm
For self-propelled units arrangement shall be provided at the main propulsion control station or at the
manoeuvring platform as appropriate for the operation of an engineers’ alarm which shall be clearly audible
in the engineers’ accommodation.
(See MODU Code 7.8)

1.5 Fire protection

1.5.1 Facilities for the safe storage and handling of flammable fluids shall be found on board.
1.5.2 All spaces where oil-burning installations, settling tanks or daily service fuel oil tanks are located shall be easily accessible and well ventilated.

1.5.3 Where small leaks of flammable fluids may occur during normal service or routine maintenance work, special arrangements shall be made to prevent these fluids from reaching other parts of the machinery where danger of ignition may arise.

1.5.4 Piping and other installations for the transport of flammable fluids shall be so located that the fire hazard resulting from rupture and other failures, is acceptably low.

1.5.5 Exhaust pipes shall not be led in the vicinity of fuel oil tanks, storage tank bulkheads.

1.5.6 All surfaces which may reach a temperature of 220°C or more, shall be insulated or equivalently protected so that flammable fluids cannot be ignited.

1.5.7 Where oil absorbing insulating material is used, the insulation shall be covered by non-combustible vapour-tight sheeting.

1.5.8 All other possible ignition sources of the machinery shall be protected in order to prevent ignition of flammable fluids.

1.5.9 Flammable or oil absorbing materials shall not be used in floors, gratings etc. in boiler and engine rooms, shaft tunnels or in compartments where settling tanks are installed.

1.5.10 Hydraulic power units shall be provided with adequate shielding in order to avoid potential oil leakage, or spray coming into contact with any sources of ignition.

1.5.11 When purifiers for heated fuel oil are not located in a separate room, consideration shall be given with regard to their location, ventilation conditions, containment of possible leakage and shielding from ignition sources.

1.5.12 Approved penetrations shall be used where pipes are passing through fire resistant bulkheads or decks.

1.6 Piping systems

1.6.1 Metallic pipes shall be connected by welding or brazing or by detachable connections in accordance with Sec.6.

1.6.2 Plastic pipes shall be connected by welding, gluing, cementing, lamination or similar methods in accordance with Sec.6 [5] or by approved detachable connections in accordance with Sec.2 [7].

1.6.3 Installation of pipes for water, steam or oil behind or above electric switchboards shall be avoided as far as possible. If this is impracticable, all detachable pipe joints and valves shall be at a safe distance from the switchboard or well shielded from it.

1.6.4 Routing of water pipes and air and sounding pipes through freezing chambers shall be avoided.
1.6.5 Piping systems shall be adequately identified according to their purpose. Valves shall be permanently and clearly marked.

1.7 Operation of valves

1.7.1 Sea suction and discharge valves located in dry compartments, bilge valves and valves on the fuel oil and lubricating oil tanks which are situated higher than the double bottom tanks, shall be arranged for local manual operation. The changeover to manual operation from possible remote control arrangement shall be simple to execute.

**Guidance note:**
Where hydraulically actuated sea suction and discharge valves are located in the engine room, a hand pump ready for use fitted to each actuator is considered acceptable as local manual operation.

---end---of---guide---note---

1.7.2 For remotely controlled valves failure in power supply or control signal shall not cause:
— opening of closed valves
— closing of open valves on fuel oil tanks and in cooling water system for propulsion and power generating machinery.

1.7.3 All valves in storage and ballast tanks which are hydraulically or pneumatically controlled shall also be arranged for manual operation, e.g. with a hand-pump connected to the control system.

1.7.4 Spindles of sea suction valves, discharge valves below the load line, emergency bilge valves in engine rooms and blow down discharge valves shall extend above the floor plates or by other means be easily accessible and visible.
For vessels with periodically unmanned machinery machinery space technical requirements in DNVGL-RU-SHIP Pt.3 Ch.12 Sec.9 [4] shall be complied with.

1.7.5 Remotely controlled valves shall be provided with indications for open and closed valve positions at the control station. In cases where the possibility of local manual operation is required in addition to the remote control, means of observing the valve position at the valve location shall be provided.

1.7.6 In addition, requirements for weathertight and watertight integrity as given in DNVGL-OS-C301, shall be complied with.

1.8 Valves on sides and bottom

1.8.1 All sea inlet and overboard discharge pipes shall be fitted with easily accessible valves or cocks secured direct to the shell or sea chest.

1.8.2 If it is impractical to fit the valves or cocks directly to the shell or sea chest, distance pieces of steel may be accepted.
These shall be made as short, rigid constructions, and shall not be of a thickness less than given in DNVGL-OS-C301 Ch.2 Sec.2 [7.2].
The distance piece shall extend through the shell plating or sea chest, and shall be welded on both sides or with full penetration welding.
If valves are bolted to pads on the hull side, the pads shall be welded to the hull side as described for distance piece above.
1.8.3 For units or installations with double side and/or bottom, the following requirements apply:

a) The valve may be fitted to the inboard tank boundary.

b) The pipe wall thickness between side and bottom and inner boundary shall be minimum 11 mm, regardless of pipe diameter and regardless the shell plating thickness.

c) Due attention shall be paid to the detail design to avoid high stresses being introduced at pipe fixations, as for example where the outer and inner boundary are connected by a short and straight pipe.

d) Outlet- or inlet-pipes passing through heated fuel oil tanks or lubricating oil tanks shall be surrounded by cofferdams.

1.8.4 All outlets and sea inlet valves shall be fitted to the shell in such a way that piping inboard of the valves may be disconnected without interfering with the watertight integrity of the shell.

1.8.5 Valves and cocks for blow down of boilers shall have a protection ring fitted on the outside of the shell plating through which the spigot shall be carried. The spigot shall terminate flush with the outer side of the ring.

1.8.6 Suction and discharge valves of steel and sea chests and distance pieces shall be protected against corrosion by an efficient coating or equivalent.

1.8.7 All suction and discharge pipes shall be adequately protected where they are liable to be damaged by cargo and equipment.

1.8.8 Sea inlets shall be so designed and arranged as to limit turbulence and to avoid entry of air due to the unit/installation’s movements.

1.8.9 Scuppers and sanitary discharges shall be arranged in accordance with DNVGL-OS_C301 Ch.2 Sec.2, as applicable.

1.8.10 Sea inlets and discharge valves for systems where plastic piping is used shall be arranged with remote closing arrangement. The adequacy of this system shall be documented.

1.8.11 Sea suctions and discharge valves for units having additional class notation for navigation in ice see DNVGL-RU-SHIPS Pt.6 Ch.6

1.9 Fittings on watertight bulkheads

1.9.1 Where a collision bulkhead is provided, any pipes penetrating collision bulkhead to be arranged in accordance with DNVGL-RU-SHIPS Pt.4 Ch.6 Sec.3.

1.9.2 No drain valve or cock shall be fitted to watertight bulkheads unless they are accessible at all times and capable of being closed from above the deep load line. Alternatively the valve shall be of the self-closing type. Indication of open and closed position of the valves and cocks shall be provided.

1.9.3 Fastening of fittings, pipes, etc. to bulkheads or tunnel plating by means of bolts passing through clearing holes in the plating is not acceptable.
1.10 Requirements dependent upon damage stability calculations

For units or installations where damage stability requirements apply, precautions shall be taken to prevent intercommunication through damaged pipe lines between flooded and intact compartments.

Guidance note:
For this purpose, where any part of a pipe system is situated within the defined damaged area and the pipe line has an open end in a compartment assumed to be intact, then an isolating valve should be fitted. The valve should be situated outside the damaged area and should be operable from the freeboard deck or from another position and accessible when the unit or installation is in damaged condition. For bilge lines, the remotely operated stop valves may be substituted by a non-return valve.

Guidance note:
For compliance with IMO MODU Code bilge lines may only be fitted with a positive closable valve operable from above the waterline.

2 Construction and function

2.1 General

2.1.1 The machinery shall be so designed, installed and protected that risks of fire, explosions, accidental pollution, leakages and accidents thereof are acceptably low.

2.1.2 Reliability and availability of the machinery shall be adapted according to considerations of the consequences from machinery failures and disturbances.

2.1.3 The design arrangement of machinery foundations, shaft connections, piping and ducting shall take into account the effects of thermal expansion, vibrations, misalignment and hull interaction to ensure operation within safe limits. Bolts and nuts exposed to dynamic forces and vibrations shall be properly secured.

2.2 Environmental conditions

2.2.1 All machinery, components and systems essential to the safe operation of a unit should be designed to operate under the following static conditions of inclination:
— column-stabilised units, from upright to an angle of inclination of 15° in any direction
— self-elevating units, from upright to an angle of inclination of 10° in any direction
— surface units, from upright and in level trim to an angle of inclination of 15° either way and simultaneously trimmed up to 5° by the bow or stern.

Guidance note:
Deviations from these angles may be required or considered, taking into consideration the type, size and service conditions of the unit.

(See MODU Code 4.1.4)

2.2.2 The emergency generator and its prime mover and any emergency accumulator battery shall be designed to function at full rated power when upright and when inclined up to the maximum angle of heel in the intact and damaged condition, as determined in accordance with DNVGL-OS-C301 Ch.2 Sec.1. In no case need the equipment be designed to operate when inclined more than:
— 25° in any direction on column-stabilised units
— 15° in any direction on self-elevating units and
— 22.5° about the longitudinal axis and/or when inclined 10° about the transverse axis on surface units.

(See MODU Code 5.4.15)

2.2.3 All components and systems covered by this standard shall be designed to operate under the following environmental conditions unless otherwise specified in the detailed requirements for the component or system:

a) Ambient air temperature in the machinery space between 0°C and 45°C.

b) Relative humidity of air in the machinery space up to 96%.

c) Sea water temperature up to 32°C.

Guidance note:
Environmental conditions for electrical are given in DNVGL-OS-D201 Ch.2 Sec.2.
Environmental conditions for instrumentation are given in DNVGL-OS-D202 Ch.2 Sec.4.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.2.4 The engine manufacturer shall not be expected to provide simulated ambient reference conditions at a test bed unless specified in the relevant standards.

2.3 Functional capability and redundancy

2.3.1 Components and systems shall be arranged with redundancy so that a single failure of any active component or system does not cause loss of any main function, as specified in DNVGL-RU-OU-0101 Ch.1 Sec.3 [1], DNVGL-RU-OU-0102 Ch.1 Sec.3 [1], DNVGL-RU-OU-0103 Ch.1 Sec.3 [1] and DNVGL-RU-OU-0104 Ch.2 Sec.1 [2]with the exceptions listed in [2.3.5].

2.3.2 Redundancy can either be arranged as component redundancy or system redundancy as defined in Ch.1 Sec.1 [4.2].

2.3.3 For redundancy on a component level a single failure of an active component shall not lead to a reduction of the output power for the main function served, as long as the main function is served by one system only.

2.3.4 For duplicated systems a single failure of an active component or a system shall not reduce the output power for the main function, served by the duplicate system, to less than 40% of the nominal output rated power. [2.3.1]and [2.3.2] shall be considered as general requirements. For evaluation of deviations or equivalent solutions reference should be made to the relevant standard for the component or system in question.

Guidance note:
For single engine propulsion plants all active components should be duplicated to satisfy [2.3.1]and [2.3.2].
Multi engine propulsion plants or propulsion plants with combinations of diesel engines, gas turbines and/or electrical motors are considered to provide redundancy on a system level. For these plants, duplication of the active components is not necessary provided at least 40% of output rated power for the main function is remaining in case of a single failure. For propulsion plants where less than 40% of output rated power remains, after a single failure, duplication of the active components will be required. Output rated power is in this context the total rated propulsion power for the driven unit (e.g. one or several propellers).
All other main functions shall be treated accordingly.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
2.3.5 The following active components are general exceptions to [2.3.1] and are not required as part of the designed redundancy, unless otherwise specified in the rules:

— main engine
— shafting, gear, driven unit (e.g. propeller)
— anchor windlass
— machinery for emergency power supply
— auxiliary thrusters.

2.3.6 Components and systems forming part of the designed redundancy are normally to be arranged as system availability R2 (see DNVGL-OS-D202 Ch.2 Sec.1 [2]). When the interruption of the function, of a duplicated component or system, entails considerable hazard to other components or systems, or to the unit or installation, system availability R1 shall be arranged. The installation can be arranged as system availability R3 if accepted in the relevant standard.

2.3.7 Active components, arranged as part of the designed redundancy, shall be so dimensioned that in the event of a single failure sufficient capacity remains to cover demands at the maximum continuous load of the component served.

Guidance note:

Only relevant for plants where it is required to have redundancy on a component level (e.g. single engine plants, see [2.3.2]).

2.3.8 When two or more components are performing the same function, these shall be mutually independent and at least one shall be independently driven. Components arranged as part of the designed redundancy, yet only performing auxiliary functions to a main unit, can be directly powered by the main unit through separate power transmissions, on the condition that these components are not necessary for the starting of the main unit.

2.3.9 The machinery shall be so arranged and designed that all main functions can be maintained simultaneously in normal service.

2.3.10 For self-propelled units maintenance tasks normally expected to occur at short intervals, for example weekly, shall be carried out without loss of propulsion or steering.

2.3.11 Change over from one normal operational mode to another normal operational mode of the machinery shall be possible without interruption in propulsion or steering.

2.3.12 Machinery or equipment having remote or automatic control, shall have additional alternative provisions for attendance and operation.

2.3.13 For mobile units the machinery shall be so arranged that it can be brought into operation from the "dead ship" condition within 30 minutes using only the facilities available on board. "Dead ship" condition is understood to mean that the entire machinery installation, including the power supply, is out of operation and that auxiliary services (such as compressed air, starting current from batteries etc.) for bringing the main propulsion into operation and for the restoration of the main power supply are not available.

In order to restore operation from the "dead ship" condition, an emergency generator may be used provided that it is ensured that the emergency power supply from it is available at all times. It is assumed that means are available to start the emergency generator at all times.

For units without a designated emergency engine in accordance with the MODU code, all main engines doubling as emergency engines shall be available for start.
2.3.14 Requirements for cold starting arrangements of floating offshore installations shall be especially
determined depending on project specific assessment of the safety hazards involved.

2.3.15 The performance and capacity of auxiliary systems shall be adapted to the needs of the machinery
installations served.

2.4 Failure effects

2.4.1 In the event of failure, components and systems shall enter the least hazardous of the possible failure
states with regard to machinery, personnel and environment.

2.4.2 The probability that failure in a component causes damage or failure to other components, shall be
acceptably low.

2.4.3 Failure of one component in a system arranged as part of the designed redundancy shall not lead to
failure or damage to backup or parallel components or systems.

2.5 Component design

2.5.1 Where no specific requirements are given in these standards regarding dimensioning and choice of
materials, generally recognised standards and engineering principles shall be applied.

2.5.2 If acceptable accuracy cannot be obtained by strength calculations, special tests for the determination
of the strength of the design may be required.

2.5.3 When it is of essential significance for the safety of the unit or installation that the function of a
component is maintained as long as possible in the event of fire, materials with high heat resistance shall be
used.

2.5.4 Materials with low heat resistance shall not be used in components where fire may cause outflow of
flammable or health hazardous fluids, flooding of any watertight compartment or destruction of watertight
integrity.

Guidance note:

Materials with high heat resistance are materials having a melting point greater than 925°C. Materials with low heat resistance are
all other materials. Deviations from the above requirement will be subject to special considerations.

3 Personnel protection

Machinery, boilers and associated piping systems shall be so installed and protected as to reduce to a
minimum any danger to persons onboard, due regard being paid to moving parts, hot surfaces and other
hazards.
SECTION 2 GENERAL PIPING DESIGN

1 General

1.1 Application

1.1.1 This section gives minimum requirements which apply to piping systems, including bends, tees, valves, fittings, flanges, flexible elements, etc.

1.1.2 The design and installation of piping systems should conform to a recognised design code or standard, subject to any modifications under the requirements in this standard.

1.1.3 Piping systems used for safe operation of the unit or installation shall in general be separate from piping systems used for drilling or production operations. If cross connections are necessary, appropriate means shall be fitted to prevent possible contamination of the safe system from any hazardous medium.

1.1.4 All requirements are based on the assumption that piping and components are subject to preventive maintenance throughout the intended lifetime of the unit or installation.

For cases where this assumption is not valid, corrosion resistant materials, additional corrosion allowance and/or special corrosion protection should be considered.

1.1.5 If a floating offshore installation other than MOU is intended to be built and disposed within the EU member states, including EEA and EFTA, the piping design including components and materials must conform to the minimum safety requirements outlined in the Pressure Equipment Directive 2014/68/EU. Exclusions from the directive are listed in article no. 1 in the directive. Harmonized European standards for the design and fabrication of materials, valves, fittings and pipes will in general fulfil the requirements outlined in the directive.

Guidance note:
The Pressure Equipment Directive may also be referred to as the PED Directive. It’s formal title is: DIRECTIVE 2014/68/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 May 2014 on the harmonisation of the laws of the member states relating to the making available on the market of pressure equipment.

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1.2 Categories of piping classification

1.2.1 Piping classification is applied on the basis of intended medium, pressure and temperature conditions.

1.2.2 The designated piping class is used to indicate the materials, manufacturing and inspection requirements which shall be applied to ensure the operational integrity of piping.

1.2.3 For the purpose of certification, testing, type of joint to be adopted, heat treatment and welding procedures, piping shall be subdivided into three classes as given in Table 1.

Guidance note:
In addition to the pressure piping systems in Table 1, class III pipes may be used for open ended piping, for example overflows, vents and open ended drains.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
Guidance note:
A project may decide to categorise systems more stringently based on considerations other than safety. Factors such as consequence of failure and ease of repair with respect to need to limit operations may also be considered.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Table 1 Classes of piping systems

<table>
<thead>
<tr>
<th>Piping system for</th>
<th>Class I 1)</th>
<th>Class II 1)</th>
<th>Class III 1) 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p (bar)</td>
<td>t (°C)</td>
<td>p (bar)</td>
</tr>
<tr>
<td>Steam</td>
<td>&gt; 16 or &gt; 300</td>
<td>≤ 16 and ≤ 300</td>
<td>≤ 7 and ≤ 170</td>
</tr>
<tr>
<td>Thermal oil</td>
<td>&gt; 16 or &gt; 300</td>
<td>≤ 16 and ≤ 300</td>
<td>≤ 7 and ≤ 150</td>
</tr>
<tr>
<td>Flammable fluids 2)</td>
<td>&gt; 16 or &gt; 150</td>
<td>≤ 16 and ≤ 150</td>
<td>≤ 7 and ≤ 60</td>
</tr>
<tr>
<td>Other media 3)</td>
<td>&gt; 40 or &gt; 300</td>
<td>≤ 40 and ≤ 300</td>
<td>≤ 16 and ≤ 200</td>
</tr>
</tbody>
</table>

p = Design pressure, as defined in [3.4.2]
t = Design temperature, as defined in [3.4.4]

1) For class II and III piping both specified conditions are to be met, for class I piping one condition only is sufficient.
2) Flammable fluids include: lubricating oil, flammable hydraulic oil, fuel oil and systems covered by Sec.4 [12].
3) Open ended pipes (drains, overflows, vents, boiler escape pipes etc.) independently of the pressure and temperature, are pertaining to class III.
4) Additional NDT requirements is applicable for class III piping for safety critical systems in oil production and storage units. See Sec.6 Table 4.

Note:
Cargo piping for chemicals or liquefied gases are not covered by the table.
Requirements for these systems are found in DNVGL-RU-SHIP Pt.5 Ch.6 and DNVGL-RU-SHIP Pt.5 Ch.7.

---e-n-d---o-f---n-o-t-e---

2 Materials

2.1 General principles

2.1.1 Materials used in piping systems shall be suitable for the medium and service for which the system is intended.
2.1.2 Materials to be used in the construction of piping systems shall be manufactured and tested in accordance with DNVGL-OS-B101.

Guidance note:
The traditional stainless steels, including type 316 or 316 L, are generally not considered suitable for use in seawater systems. However, certain stainless steels with higher contents of chromium, molybdenum and nitrogen have improved resistance to localised corrosion. These include high molybdenum austenitic steels and ferritic-austenitic (duplex) steels. Even these steels cannot be considered immune to attack under all situations; avoidance of stagnant seawater conditions and removal of welding oxides are some of the important factors to the successful use.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.3 For galvanized steel air vent heads, the zinc coating shall be applied by the hot method and the thickness shall be 70-100 microns.
(See IACS UR P3.3.2)

2.1.4 Non-ferrous metallic materials with melting points higher than 925°C may be accepted in piping systems as an alternative to steel except where specific limitation are given elsewhere in the offshore standards.
Non-ferrous metallic materials with melting point lower than 925°C may be used under the same restrictions as for plastic pipes. See [2.5].

2.2 Carbon and low alloy steel

2.2.1 Steel pipes for application as class I or class II shall be seamless drawn pipes. Welded pipes may be accepted for class I and II pipes where delivered in accordance with DNVGL-OS-B101.

2.2.2 Cast and forged carbon and carbon manganese steel may be used for temperatures up to 400°C. Application at higher temperatures may be acceptable provided that:
— metallurgical behaviour and time dependent strength (ultimate tensile strength after 100 000 hours) are in accordance with national or international codes or standards, and
— such values are guaranteed by the steel manufacturer.

2.2.3 Where the above conditions cannot be met, special heat resisting alloy steels shall be used.

2.3 Copper and copper alloys

2.3.1 Copper and copper alloy pipes for application as class I or class II shall be of seamless drawn material in accordance with DNVGL-OS-B101.

2.3.2 Copper and copper alloys shall not be used for media having temperature above the limits given in Table 2.

Table 2 Operating temperature limits of copper and copper alloy piping

<table>
<thead>
<tr>
<th>Piping material</th>
<th>Temperature limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper and aluminium brass</td>
<td>200°C</td>
</tr>
<tr>
<td>Copper nickel</td>
<td>300°C</td>
</tr>
<tr>
<td>Special bronze suitable for high temperature service</td>
<td>260°C</td>
</tr>
</tbody>
</table>

2.3.3 Copper or copper alloys shall not be used for pipes with outer diameter > 44.5 mm for compressed air service with pressure above 20 bar.

2.4 Cast iron

2.4.1 Grey cast iron shall not to be used for piping subject to pressure shock, excessive strains and vibration.

2.4.2 Grey cast iron shall not be used for class I and II piping with the following exceptions:
— components in hydraulic piping systems where failure would not render the system inoperative or introduce a fire risk
— pump and filter housings in fuel and lubrication oil systems where the design temperature does not exceed 120°C.

2.4.3 Grey cast iron may be used for class III piping, with the following exceptions:
— pipes and valves fitted on the unit or installation sides and bottom and on sea chests
— valves fitted on collision bulkhead
— valves under static head fitted on the external wall of fuel tanks, lub. oil tanks and tanks for other flammable fluids
— bilge and ballast lines in tanks
— valves for fluids with temperatures in excess of 120°C.

2.4.4 Nodular cast iron of the ferritic type, with a specified minimum elongation of 12%, may be used in class II and III piping, in pipes and valves located on the unit or installation's side and bottom, and valves on the collision bulkhead.
2.4.5 The use of nodular cast iron in class I piping shall be subject to special consideration on a case by case basis.

2.4.6 Nodular cast iron shall not be used for media having a temperature exceeding 350°C. The use of nodular cast iron for media having a temperature below 0°C shall be considered in each particular case.

2.4.7 Nodular cast iron of the ferritic/pearlitic and pearlitic type shall normally be subject to the same limitations of use as for grey cast iron in [2.4.1] and [2.4.2]. In addition, nodular cast iron pipes of the ferritic/pearlitic type with an elongation $A_5$ of at least 7% may be used in bilge and ballast lines in pipe tunnels in double bottom.

2.5 Plastic pipes

2.5.1 Plastic pipes used in systems and locations according to Table 3 shall meet the requirements specified therein. The permitted use and the requirements for the piping are in conformance with IMO Resolution A.753(18) Guidelines for the Application of Plastic Pipes on Ships.

2.5.2 All pipes, except those fitted on open decks and within tanks, cofferdams, pipe tunnels and ducts, if separated from accommodation, permanent manned areas and escape ways by means of an A class bulkhead, shall have low surface flame spread characteristics not exceeding average values listed in IMO Resolution A.753(18) Appendix 3. Surface flame spread characteristics shall also be determined using the test procedures given in ASTM D635 or in other national equivalent standards.

2.5.3 Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance level required, it shall meet the following requirements:

a) The pipes shall be delivered from the manufacturer with the protective coating on.

b) The fire protection properties of the coating shall not be diminished when exposed to saltwater, oil or bilge slops. It shall be demonstrated that the coating is resistant to products likely to come into contact with the piping.

c) In considering fire protection coatings, such characteristics as thermal expansion, resistance against vibrations, and elasticity shall be taken into account.

d) The fire protection coatings shall have sufficient resistance to impact to retain their integrity.

**Guidance note:**
Alternatively to [2.5.1] to [2.5.3] the approach for establishing design performance requirements given in UKOOA document Specification and Recommended Practice for use of GRP piping offshore, may be used.

2.5.4 In addition to the use permitted by Table 3 plastic pipes may also be used for pneumatic and hydraulic control pipes within closed control cabinets, with the following exceptions:

— steering gear
— systems for remote control of:
  — fire extinguishing systems
  — seawater valves (ballast and cooling)
  — valves on fuel oil service tanks
  — valves in bilge and fuel oil systems.
2.5.5 Plastic pipes used in piping systems subject to classification shall be of approved type and tested to an approved specification observing the requirements in [3.8].

Guidance note:
Plastic pipes used in air bubbling systems for sounding of tanks are subject to classification and is therefore required to be type approved in accordance with the above.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Table 3 Fire endurance requirements matrix

<table>
<thead>
<tr>
<th>Location</th>
<th>A</th>
<th>B</th>
<th>C</th>
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<th>E</th>
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<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
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</thead>
<tbody>
<tr>
<td><strong>Piping systems</strong></td>
<td></td>
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<tr>
<td>Fuel oil tanks</td>
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<tr>
<td>Ballast water tanks</td>
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<tr>
<td>Cofferdams, void spaces, pipe</td>
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<tr>
<td>tunnel and ducts</td>
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<tr>
<td>Accommodation service and</td>
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</tr>
</tbody>
</table>

**CARGO** Flammable fluids or liquids (flash point ≤ 60°C)

1. Crude or oil product lines   | NA | NA | L1 | NA | 0 | NA | 0 | 9) | 0 | NA | L1 2)
2. Crude oil washing lines     | NA | NA | L1 | NA | 0 | NA | 0 | 9) | 0 | NA | L1 2)
3. Vent lines                  | NA | NA | NA | NA | 0 | NA | 0 | 9) | 0 | NA | X

**INERT GAS**

4. Water seal effluent line     | NA | NA | 0 1) | NA | 0 1) | 0 1) | 0 1) | 0 1) | NA | 0
5. Scrubber effluent line       | 0 1) | 0 1) | NA | NA | NA | NA | 0 1) | 0 1) | NA | 0
6. Main line                    | 0 | 0 | L1 | NA | NA | NA | NA | 0 | NA | L1 6)
7. Distribution lines           | NA | NA | L1 | NA | 0 | NA | NA | 0 | NA | L1 2)

**FLAMMABLE LIQUIDS** (flash point > 60°C)

8. Crude or oil product lines   | X | X | L1 | X | NA 3) | 0 | 0 9) | 0 | NA | L1
9. Fuel oil                     | X | X | L1 | X | NA 3) | 0 | 0 | 0 | L1 | L1
10. Lubricating oil             | X | X | L1 | X | NA | NA | NA | NA | 0 | L1 | L1
11. Hydraulic oil               | X | X | L1 | X | 0 | 0 | 0 | 0 | L1 | L1

**SEAWATER** 1)

12. Bilge main and branches     | L1 | L1 | L1 | X | 0 | 0 | 0 | 0 | NA | L1
13. Fire main and water spray   | L1 | L1 | L1 | NA | NA | NA | NA | 0 | X | L1
### Piping systems

<table>
<thead>
<tr>
<th>Location</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
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#### FRESHWATER

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<th>D</th>
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<th>I</th>
<th>J</th>
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<td>Cooling water, essential services</td>
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#### SANITARY OR DRAINS OR SCUPPERS

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<th>C</th>
<th>D</th>
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<tr>
<td>Deck drains (internal)</td>
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<td>Scuppers and discharges (overboard)</td>
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<td>L1</td>
<td>L1</td>
<td>L1</td>
<td>L1</td>
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#### SOUNDING OR AIR

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<tr>
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<th>C</th>
<th>D</th>
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<th>G</th>
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<th>I</th>
<th>J</th>
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<tbody>
<tr>
<td>Water tanks/dry spaces</td>
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</tr>
<tr>
<td>Oil tanks (flash point &gt; 60°C)</td>
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#### MISCELLANEOUS

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</thead>
<tbody>
<tr>
<td>Control air</td>
<td>L1</td>
<td>L1</td>
<td>L1</td>
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<td>Service air (non-essential)</td>
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</table>
### Abbreviations used

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Fire endurance test in dry conditions, 60 minutes Appendix 1 of IMO Res. A.753(18)</td>
</tr>
<tr>
<td>L2</td>
<td>Fire endurance test in dry conditions, 30 minutes Appendix 1 of IMO Res. A.753(18)</td>
</tr>
<tr>
<td>L3</td>
<td>Fire endurance test in wet conditions, 30 minutes Appendix 2 of IMO Res. A.753(18)</td>
</tr>
<tr>
<td>0</td>
<td>No fire endurance test required</td>
</tr>
<tr>
<td>NA</td>
<td>Not applicable</td>
</tr>
<tr>
<td>X</td>
<td>Metallic materials having a melting point greater than 925°C.</td>
</tr>
</tbody>
</table>

### Notes:

1. Where non-metallic piping is used, remotely controlled valves to be provided at unit’s side (valve shall be controlled from outside space).
2. Remote closing valves to be provided at the storage tanks.
3. When storage tanks contain flammable liquids with flash point > 60°C, «0» may replace «NA» or «X».
4. For drains serving only the space concerned, «0» may replace «L1».
5. When controlling functions are not required by statutory requirements or guidelines, «0» may replace «L1».
6. For pipe between machinery space and deck water seal, «0» may replace «L1».
7. Scuppers serving open decks in positions 1 and 2, as defined in regulation 13 of the International Convention on Load Lines, 1966, should be «X» throughout unless fitted at the upper end with the means of closing capable of being operated from a position above the freeboard deck in order to prevent downflooding.
8. For essential services, such as fuel oil tank heating and unit’s whistle, «X» is to replace «0».
9. For storage units where compliance with paragraph 3.6 of regulation 19 of Annex I of MARPOL 73/78 is required, «NA» is to replace «0».

### Location definitions:

<table>
<thead>
<tr>
<th>Location</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Machinery spaces of category A</td>
<td>Machinery spaces of category A as defined in MODU Code 2009, Chapter 1, 3.34.</td>
</tr>
</tbody>
</table>
### Piping systems

<table>
<thead>
<tr>
<th>Location</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery spaces of category A</td>
<td>Other machinery spaces</td>
<td>Cargo pump rooms</td>
<td>Dry cargo holds</td>
<td>Cargo tanks</td>
<td>Fuel oil tanks</td>
<td>Ballast water tanks</td>
<td>Cofferdams, void spaces, pipe tunnel and ducts</td>
<td>Accommodation service and control spaces</td>
<td>Open decks</td>
<td></td>
</tr>
</tbody>
</table>

**B - Other machinery spaces and pump rooms**
Spaces, other than category A machinery spaces and cargo pump rooms, containing propulsion machinery, boilers, steam and internal combustion engines, generators and major electrical machinery, pumps, oil filling stations, refrigerating, stabilizing, ventilation and airconditioning machinery, and similar spaces, and trunks to such spaces.

**C - Cargo pump rooms**
Spaces containing cargo pumps and entrances and trunks to such spaces.

**D - Dry cargo holds**
Cargo holds used for non-liquid cargo and trunks to such spaces.

**Guidance note:**
Ro-ro cargo holds are not covered by this standard.

---end of guidance note---

**E - Cargo tanks**
All spaces used for liquid cargo and trunks to such spaces.

**F - Fuel oil tanks**
All spaces used for fuel oil (excluding cargo tanks) and trunks to such spaces.

**G - Ballast water tanks**
All spaces used for ballast water and trunks to such spaces.

**H - Cofferdams, void spaces, pipe tunnel and ducts**
Cofferdams and voids are those empty spaces between two bulkheads separating two adjacent compartments.

**I - Accommodation, service and control spaces**
Accommodation spaces, service spaces and control stations as defined in MODU Code 2009 Chapter 1, 3.3.

**J - Open decks**
Open deck spaces as defined in MODU Code 2009 Chapter 9, 2.5.2(10).

### 2.5.6 Use of GRE/GRP piping in firewater systems shall be subject to special consideration with respect to use of standard fire testing methods. The following parameters shall be evaluated:

- results of fire testing
- whether pipe is continuously water filled in service
- location of pipe with respect to likely fire source
- possibility of pipe being engulfed in fire
- possibility of isolation of any damaged section.
Guidance note:

See USCG PFM 1-98: Policy File Memorandum on the Fire Performance Requirements for Plastic Pipe per IMO Resolution A.753(18).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.6 Flanges, valve bodies, etc.

2.6.1 Flanges, valve bodies, etc., shall normally be forged or cast and the material shall be suitable for the design temperature.

2.6.2 If components are manufactured from forged bar stock, rolled bar stock, forged plate or rolled plate, the material shall be tested in the transverse direction and is to meet the requirements for longitudinal specimens of forged to shape components. Where plate materials are used, additional testing shall be carried out in the short – transverse direction of the materials.

2.7 Bolts and nuts

2.7.1 Bolts and nuts for class I and II piping shall conform to a recognised standard, e.g. ISO 898.

2.7.2 Major pressure retaining bolts and nuts with specified minimum yield stress above 490 N/mm$^2$ shall be made of alloy steel, i.e. (% Cr+% Mo+% Ni) ≥ 0.50, and shall be supplied in the quenched and tempered condition.

2.7.3 For general service in atmospheric environment, the specified tensile properties shall not exceed ISO 898 property class 10.9.

2.7.4 Where equipment shall be submerged in seawater, the tensile properties shall not exceed property class 8.8 or equivalent.

2.8 Material certificates

The materials used in piping systems shall be provided with documentation given in Table 5. For definition of types of documentation of material quality and testing, see Table 4.

**Table 4 Material certification**

<table>
<thead>
<tr>
<th>Certification process</th>
<th>ISO 10474 (EN 10204)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test report</td>
<td>2.2</td>
</tr>
<tr>
<td>Confirmation by the manufacturer that the supplied products fulfil the purchase specification, and test data from regular production, not necessarily from products supplied</td>
<td></td>
</tr>
<tr>
<td>Inspection certificate (works certificate)</td>
<td>3.1</td>
</tr>
<tr>
<td>Test results of all specified tests from samples taken from the products supplied. Inspection and tests witnessed and signed by QA department</td>
<td></td>
</tr>
<tr>
<td>Inspection certificate (test certificate)</td>
<td>3.2</td>
</tr>
<tr>
<td>As work certificate, inspection and tests witnessed and signed by QA department and an independent third party body</td>
<td></td>
</tr>
</tbody>
</table>
## Table 5 Material certificates

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Class of piping system</th>
<th>Nominal diameter (mm)</th>
<th>Design temperature (°C)</th>
<th>Type of documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>&gt; 50</td>
<td></td>
<td>3.2 certificate</td>
</tr>
<tr>
<td>Pipes 1)</td>
<td></td>
<td>II, III</td>
<td>&gt; 50</td>
<td></td>
<td>3.1 certificate</td>
</tr>
<tr>
<td>Flanges and bolts 3) 4)</td>
<td></td>
<td></td>
<td>&gt; 400</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Bodies of valves and fittings 1), source materials of steel expansion bellows, other pressure containing components not considered as pressure vessels</td>
<td>Steel 2)</td>
<td>I</td>
<td>&gt; 100</td>
<td>&gt; 400</td>
<td>2.2 report</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>≤ 100</td>
<td>&gt; 400</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steel or nodular cast iron</td>
<td>I, II</td>
<td>&gt; 100</td>
<td>≤ 400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>III</td>
<td>≤ 100</td>
<td>≤ 400</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Cast iron</td>
<td>III</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Copper alloys 2)</td>
<td>I, II</td>
<td>&gt; 50</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td>III</td>
<td>≤ 50</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Pump housings</td>
<td></td>
<td>I</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td>II, III</td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

1) Pipes and bodies of valves fitted on unit or installation’s side and bottom and bodies of valves fitted on collision bulkhead shall be provided with documentation as required for class II piping systems.
2) When fittings are made from plates or pipes, the certification requirements for pipes shall be applied also for pipe fittings.
3) Not applicable for exhaust gas systems.
4) Bolts as specified in [2.7.2] shall be delivered with 3.2 certificate.
3 Design conditions

3.1 Principles

3.1.1 External and internal attachments to piping shall be designed so that they will not cause flattening of pipe, excessive local bending stresses, or harmful thermal gradients in the pipe wall. Constructions causing stress concentrations shall be minimised, particularly in cyclic service applications.

3.1.2 All components in a system shall be satisfactorily matched with regard to function, capacity and strength. Relative motions between parts of the piping system shall be accommodated without inducing detrimental stresses.

3.1.3 Piping systems shall consist of permanently installed pipes and fittings. The piping system shall be designed and installed such that:
— weight of piping is not supported by connected machinery
— heavy valves and fittings do not cause large additional stress in adjacent pipes
— axial forces due to internal pressure, change in direction or cross-sectional area and movement of the installation or unit are considered
— the support of the piping system shall be such that detrimental vibrations will not arise in the system.

3.2 Pressure relief

Pressure containing systems shall normally be designed to withstand the maximum internal pressure which can be exerted under any conditions. Where this is not practicable, the system shall be provided with means of pressure relief.

3.3 Minimum wall thickness

3.3.1 Minimum nominal wall thickness for pipes of copper and copper alloys, steel and stainless steel pipes are given in Table 6, Table 7 and Table 8, respectively. For special applications where the pipes can be subject to excessive external loading or are inaccessible during service, increased wall thickness shall be considered. Piping under internal pressure shall also meet the requirements of [3.4].

Guidance note:
The outer diameters and wall thicknesses given in the tables are in accordance with ISO-standards. For pipes covered by other standards, thickness slightly less may be accepted.

Guidance note:
Allowance for negative tolerance or reduction in thickness due to bending is not normally required.

3.3.2 Nominal wall thickness of bilge and ballast pipes and fittings of nodular cast iron, shall not be less than:

\[ T = K \times (0.5 + 0.001 D_n) \text{ (mm)} \]

\[ D_n = \text{nominal diameter (mm)} \]
K = 9 for pipes
    = 12 for fittings other than tees
    = 14 for tees

3.4 Calculation of wall thickness of pipes being subject to internal pressure

3.4.1 The nominal wall thickness of pipes subjected to internal pressure shall be calculated as specified in [3.4], but shall not be less than specified in [3.3].

Definition of symbols:

- \( t_1 \) = nominal wall thickness (mm)
- \( t_0 \) = strength thickness (mm)
- \( t \) = minimum required wall thickness (mm)
- \( c \) = corrosion allowance (mm)
- \( b \) = bending allowance (mm)
- \( \sigma_t \) = permissible stress (N/mm\(^2\))
- \( \sigma_b \) = specified minimum tensile strength of the material at 20°C (N/mm\(^2\))
- \( \sigma_{ft} \) = specified minimum yield stress or 0.2% proof stress of the material at design material temperature (N/mm\(^2\))
- \( p \) = design pressure (bar)
- \( D \) = outer diameter of pipe (mm)
- \( \sigma_{b 100 000} \) = average value for stress to rupture after 100 000 hours at design material temperature (N/mm\(^2\))
- \( a \) = percentage negative manufacturing tolerance
- \( e \) = strength ratio.

3.4.2 The design pressure, \( p \), to be used in the formula in (3.4.8], is defined as the maximum working pressure, and shall not be less than the highest set pressure of the safety valve or relief device.

3.4.3 The design pressure requirement stated above shall apply subject to the following special considerations:

a) For pipes which are connected to pumps, \( p \) shall be equal to the maximum pump pressure, i.e. the safety valve set pressure for displacement pumps, and the maximum pressure on the head-capacity characteristic for centrifugal pumps.

b) When determining the maximum working pressure \( p \), consideration shall be given to possible pressure surges in the piping.

c) For steam pipes between boiler and superheater, steam pipes from the superheater, and where the superheater safety valve is controlled by a pilot valve operated by the steam pressure in the saturated steam drum, the design pressure \( p \) shall be taken equal to the set pressure of this safety valve.

d) For pipes without safety valves and pressure gauges on the low-pressure side of pressure-reducing valves, \( p \) shall be taken equal to the pressure on the high-pressure side of the pressure-reducing valve.

e) For feed pipes, \( p \) shall be taken equal to 1.25 times the boiler design pressure.
Table 6 Minimum nominal wall thickness for pipes of copper and copper alloys

<table>
<thead>
<tr>
<th>External pipe diameter D (mm)</th>
<th>Copper</th>
<th>Copper alloy</th>
</tr>
</thead>
<tbody>
<tr>
<td>D ≤ 10</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>10 &lt; D ≤ 20</td>
<td>1.2</td>
<td>1</td>
</tr>
<tr>
<td>20 &lt; D ≤ 44.5</td>
<td>1.5</td>
<td>1.2</td>
</tr>
<tr>
<td>44.5 &lt; D ≤ 76.1</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>76.1 &lt; D ≤ 108</td>
<td>2.5</td>
<td>2</td>
</tr>
<tr>
<td>108 &lt; D ≤ 159</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>159 &lt; D ≤ 267</td>
<td>3.5</td>
<td>3</td>
</tr>
<tr>
<td>267 &lt; D ≤ 470</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td>470 &lt; D ≤ 508</td>
<td>4.5</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 7 Minimum nominal wall thickness for steel pipes (except pipes covered by load line regulations)

<table>
<thead>
<tr>
<th>External diameter D (mm)</th>
<th>Pipes in general 3) 4) 5) 6) 7) 8)</th>
<th>Air, overflow and sounding pipes for structural tanks 1) 2) 3) 5) 6) 7) 8)</th>
<th>Bilge, ballast and general seawater pipes 1) 3) 4) 5) 7) 8)</th>
<th>Bilge, air, overflow and sounding pipes through ballast and fuel oil tanks ballast lines through fuel oil tanks and fuel oil lines through ballast tanks 1) 2) 3) 4) 5) 7) 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.2 &lt; D ≤ 12</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.5 &lt; D ≤ 17.2</td>
<td>1.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.3 &lt; D ≤ 25</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.9 &lt; D ≤ 33.7</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38 &lt; D ≤ 44.5</td>
<td>2</td>
<td>4.5</td>
<td>3.6</td>
<td>6.3</td>
</tr>
<tr>
<td>48.3</td>
<td>2.3</td>
<td>4.5</td>
<td>3.6</td>
<td>6.3</td>
</tr>
<tr>
<td>51 &lt; D ≤ 63.5</td>
<td>2.3</td>
<td>4.5</td>
<td>4</td>
<td>6.3</td>
</tr>
<tr>
<td>70</td>
<td>2.6</td>
<td>4.5</td>
<td>4</td>
<td>6.3</td>
</tr>
<tr>
<td>76.1 &lt; D ≤ 82.5</td>
<td>2.6</td>
<td>4.5</td>
<td>4.5</td>
<td>6.3</td>
</tr>
<tr>
<td>88.9 &lt; D ≤ 108</td>
<td>2.9</td>
<td>4.5</td>
<td>4.5</td>
<td>7.1</td>
</tr>
<tr>
<td>114.3 &lt; D ≤ 127</td>
<td>3.2</td>
<td>4.5</td>
<td>4.5</td>
<td>8</td>
</tr>
<tr>
<td>133 &lt; D ≤ 139.7</td>
<td>3.6</td>
<td>4.5</td>
<td>4.5</td>
<td>8</td>
</tr>
<tr>
<td>152.4 &lt; D ≤ 168.3</td>
<td>4</td>
<td>4.5</td>
<td>4.5</td>
<td>8.8</td>
</tr>
<tr>
<td>177.8</td>
<td>4.5</td>
<td>5</td>
<td>5</td>
<td>8.8</td>
</tr>
<tr>
<td>193.7</td>
<td>4.5</td>
<td>5.4</td>
<td>5.4</td>
<td>8.8</td>
</tr>
</tbody>
</table>
Table 8 Minimum wall thickness for stainless steel pipes

<table>
<thead>
<tr>
<th>External diameter D (mm)</th>
<th>Minimum wall thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.2 &lt; D ≤ 17.2</td>
<td>1.0</td>
</tr>
<tr>
<td>21.3 &lt; D ≤ 48.3</td>
<td>1.6</td>
</tr>
<tr>
<td>60.3 &lt; D ≤ 88.9</td>
<td>2.0</td>
</tr>
<tr>
<td>114.3 &lt; D ≤ 168.3</td>
<td>2.3</td>
</tr>
<tr>
<td>219.1</td>
<td>2.6</td>
</tr>
<tr>
<td>273.0</td>
<td>2.9</td>
</tr>
<tr>
<td>323.9 &lt; D ≤ 406.4</td>
<td>3.6</td>
</tr>
<tr>
<td>D &gt; 406.4</td>
<td>4.0</td>
</tr>
</tbody>
</table>

**NOTE:**
The external diameters and thickness have been selected from ISO 1127. For pipes covered by other standards, slightly reduced thickness may be acceptable.

3.4.4 The design temperature to be considered for determining the permissible stresses shall be the maximum temperature of the medium inside the pipe.
3.4.5 The design temperature requirements in [3.4.4] shall apply subject to the following special conditions:
— For steel pipes and pipes of copper and copper alloys, whose working temperature is lower than 50°C, the
design temperature shall be taken equal to 50°C.
— For saturated steam, the design temperature shall be equal to the saturation temperature.
— For superheated steam with manual steam temperature regulation, the design temperature shall be taken
at least equal to the steam temperature +15°C.
— For installations with automatic temperature control of the superheated steam, the design temperature
may be equal to the steam temperature +5°C.

Guidance note:
For manual or automatic temperature control of superheated steam, it is assumed that any temperature fluctuations greater than
15° or 5°C above the normal working temperature will be of short duration.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.4.6 The minimum wall thickness of a straight or bent pipe shall not be less than:

\[ t = t_0 + c \]

3.4.7 If the pipe shall be bent, the minimum wall thickness before bending shall not be less than:

\[ t + b \]

3.4.8 Strength thickness
The strength thickness, \( t_0 \), shall not be less than calculated by the following formula:

\[ t_0 = \frac{pD}{20 \sigma_t e + p} \]

3.4.9 The formula in [3.4.8] is valid for pipes having a ratio of wall thickness to outside diameter of 0.17 or
less. Where this ratio exceeds 0.17, the calculation shall be given special consideration.

3.4.10 For steel pipes the permissible stress, \( \sigma_t \), is in general to be based on the lower value of the
following criteria:

\[ \frac{\sigma_y}{2.7} \text{ and } \frac{\sigma_u}{1.6} \text{ (for austenitic) or } \]
\[ \frac{\sigma_p}{1.8} \text{ and } \frac{\sigma_{d10000}}{1.8} \text{ (for other materials)} \]

Values for specified minimum yield or proof stress shall be in accordance with recognised standards given in
DNVGL-OS-B101.
### Table 9 Tensile strength and permissible stress in pipes of copper and copper alloys

<table>
<thead>
<tr>
<th>Pipe material</th>
<th>Minimum tensile strength (N/mm²)</th>
<th>Design temperature (°C)</th>
<th>Permissible stress (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>up to 50</td>
<td>75</td>
</tr>
<tr>
<td>Copper, annealed</td>
<td>220</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Copper, ‹‹semi-hard››</td>
<td>250</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Aluminium-Brass ‹› annealed</td>
<td>330</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Copper-Nickel 90/10 annealed</td>
<td>290</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Copper-Nickel 70/30 annealed</td>
<td>360</td>
<td>83</td>
<td>81</td>
</tr>
</tbody>
</table>

1) For pipes conveying compressed air, the permissible stresses shall be reduced by 50% if the pressure is pulsating.

2) Cu: 76.0-79.0; Al: 1.8-2.3; As: 0.02-0.06; Zn: remainder

#### 3.4.11
For pipes made of copper and copper alloys the permissible stresses are given in Table 9 which refers to copper and copper alloys specified in DNVGL-OS-B101.

#### 3.4.12
For pipes made of materials other than steel, copper or copper alloys, the permissible stresses shall be especially considered.

#### 3.4.13
For seamless pipes, including welded pipes from manufacturers who are qualified as providing welded pipes considered equivalent to seamless pipes, the strength ratio e = 1 applies. For welded pipes from other pipe manufacturers e = 0.9 applies.

#### 3.4.14 Bending allowance
In cases where the allowance for bending, b, is not determined by a more accurate method, or where the bending procedure does not include control of the wall thickness, the allowance shall not be less than:

\[
b = \frac{1}{2.5} \frac{D}{R}^1.0
\]

\[R = \text{mean radius of the bend (mm)}\]

\[\frac{D}{R} = \text{The bending ratio}\]

Where the bending ratio is not available, this ratio will be taken equal to 1:3.

#### 3.4.15 Corrosion allowance
The corrosion allowance, c, for steel pipes shall be as specified in Table 10. Subject to the following special requirements where applicable:
a) For pipes of copper, brasses, copper-tin alloys and Cu-Ni alloys with Ni-content < 10%, the corrosion allowance shall be 0.8 mm.
b) For pipes of Cu-Ni alloys with Ni-content ≥ 10%, the corrosion allowance shall be 0.5 mm.
c) The corrosion allowance may be reduced to zero where the medium has negligible corrosive effect on the material employed.
d) A greater corrosion allowance should be considered for pipes where there is a risk of heavy corrosion and/or erosion.

### Table 10 Corrosion allowance for steel pipes

<table>
<thead>
<tr>
<th>Piping service</th>
<th>c (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superheated steam</td>
<td>0.3</td>
</tr>
<tr>
<td>Saturated steam</td>
<td>0.8</td>
</tr>
<tr>
<td>Steam coils in cargo tanks</td>
<td>2</td>
</tr>
<tr>
<td>Feed water for boilers in open circuit systems</td>
<td>1.5</td>
</tr>
<tr>
<td>Feed water for boilers in closed circuit systems</td>
<td>0.5</td>
</tr>
<tr>
<td>Blowdown pipes (for boilers)</td>
<td>1.5</td>
</tr>
<tr>
<td>Compressed air</td>
<td>1</td>
</tr>
<tr>
<td>Hydraulic oil</td>
<td>0.3</td>
</tr>
<tr>
<td>Lubricating oil</td>
<td>0.3</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>1</td>
</tr>
<tr>
<td>Cargo oil</td>
<td>2</td>
</tr>
<tr>
<td>LPG</td>
<td>0.3</td>
</tr>
<tr>
<td>Refrigerants</td>
<td>0.3</td>
</tr>
<tr>
<td>Fresh water</td>
<td>0.8</td>
</tr>
<tr>
<td>Sea water in general</td>
<td>3</td>
</tr>
</tbody>
</table>

1) For pipes passing through tanks, an additional allowance for external corrosion shall be considered according to the figures given in the Table, depending on the external medium.
2) For pipes efficiently protected against corrosion, the corrosion allowance may upon approval be reduced up to 50%.
3) For stainless steels the corrosion allowance may be omitted.

#### 3.4.16
The value of $t$ does not account for any negative manufacturing tolerance, therefore the nominal wall thickness, $t_1$, shall not be less than:

$$t_1 = \frac{t}{1 - \frac{a}{100}}$$

#### 3.4.17
The minimum wall thickness of branch pipe, including main pipe in way of branch connections, shall be determined according to a recognised standard and using permissible stresses in accordance with [3.4.12]. Alternatively, the thickness may be calculated according to [3.4.10]. However, the validity of [3.4.18] is limited by a maximum ratio for branch lines wall thickness/main line wall thickness of 2.
**3.4.18** The minimum pipe wall thickness of main pipes at a branch connection shall not be less than:

\[ t = t_0 + c \quad \text{(mm)} \]

**3.4.19** In the above equation:

\[ t_0 = \frac{pD}{20\sigma_t e + p} \]

\[ e = \text{The strength ratio, expressed by the formula:} \]

\[ e = e_1 \sin \gamma \frac{1.25}{1.25 + \frac{d_{\max} - d_{\min}}{2d_{\min}}} \]

\[ e_1 = \text{basic strength ratio. The variation with parameter } \frac{D_b}{\sqrt{D_t}} \text{ is shown in Figure 1.} \]

\[ d_{\max}, d_{\min} = \text{maximum and minimum diameter of extruded opening in the main pipe, respectively (see Figure 2).} \]

\[ \gamma = \text{angle between centre lines of main pipe and branch } \gamma \text{ is not to be less than } 45^\circ. \]

![Figure 1 Basic strength ratio](image-url)
Figure 2 Details of main pipe and branch pipe
Figure 3 Examples of acceptable branch connections for steam at temperatures above 400°C and for liquefied gases with temperature below -110°C
3.5 Thermal expansion stresses

For piping systems for steam at temperatures above 400°C, an analysis of thermal stresses shall be performed, see DNVGL-RU-SHIPS Pt.4 Ch.6 Sec.9 [1.6].

Guidance note:
In the following special cases, the analysis is not considered to be necessary:
— when the proposed piping system is considered equivalent to a successfully operating and approved installation.
— when the proposed piping system, on being closely examined, may be regarded as being in no way inferior to a previously approved installation.

3.6 Documentation of thermal stress calculation

3.6.1 When an analysis of the piping system is necessary, full details of the thermal stress calculations shall be submitted for approval. All assumptions and approximations which are made, shall be stated clearly.

3.6.2 Plans or diagrams of the proposed piping system, including specifications of coordinate axes, pipe lengths, bend radius in pipe bends, together with information on suspension details shall be submitted. When the piping system has been subject to initial pre-stressing, the degree and location of the same shall be stated.

Guidance note:
Documentation of piping stress analysis may be according to DNVGL-RP-D101 Sec.3.17.

3.7 Piping flexibility and support

3.7.1 The piping system shall be provided with sufficient flexibility to prevent movement and damage of pipes as a result of thermal expansion and dynamic and static structural deflections.

Guidance note:
The movement due to thermal variations may be approximated as stipulated below:

<table>
<thead>
<tr>
<th>Material</th>
<th>Movement (mm per °C per 100 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon steel pipes</td>
<td>1.16</td>
</tr>
<tr>
<td>Austenitic steel pipes</td>
<td>1.35</td>
</tr>
<tr>
<td>Copper alloy</td>
<td>1.42</td>
</tr>
<tr>
<td>GRP/GRE pipes</td>
<td>2-3</td>
</tr>
</tbody>
</table>

3.7.2 Use of expansion joints or expansion bends shall be considered for piping fitted on deck and near bottom which can be subject to seagoing hull deflections.

Guidance note:
Deflection of the hull girder may be approximated as follows:
For ship-shaped units made of mild steel, a deflection of ±0.85 mm/m may be used.
For ship-shaped units made of high tensile steel, a deflection ±1.2 mm/m in longitudinal direction at deck elevation may be used.

3.8 Plastic pipes
3.8.1 The nominal internal pressure for a pipe shall be determined by either:
— dividing the short-term hydrostatic test failure pressure by a safety factor of 4 or
— dividing the long-term hydrostatic (> 100 000 hour) test failure pressure by a safety factor 2.5
whichever is the lesser.

3.8.2 The hydrostatic test failure pressure shall be verified experimentally or by a combination of testing and calculation methods according to a recognised standard.

3.8.3 The nominal external pressure for a pipe shall not be less than 1 bar and shall be determined by dividing the collapse test pressure by a safety factor of 3. The collapse test pressure shall be verified experimentally or by a combination of testing and calculation methods according to a recognised standard.

3.8.4 High temperature limits and pressure reductions relative to nominal pressures should be according to the recognised standard subject to [3.8.5].

3.8.5 The maximum working temperature shall be at least 20°C lower than the minimum heat distortion temperature (determined according to ISO 75 method A, or equivalent) of the resin or plastic material. The minimum heat distortion temperature should not be less than 80°C.

3.8.6 Temperature limits and pressure reductions shall be as shown in Table 11 and Table 12 for some material types. These limits may be extended on the basis of acceptable documentation from the pipe manufacturer. The permissible temperatures stated are for long term service. Short periods of marginally higher temperatures may be acceptable based on case by case considerations.

3.8.7 The tables are related to water service only. Services involving other media shall be addressed on a case by case basis.

Table 11 Thermoplastic pipes. Permissible pressures and temperature limits

<table>
<thead>
<tr>
<th>Material</th>
<th>Nominal pressure (bar)</th>
<th>Permissible working pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- 20 to 0°C</td>
<td>30°C</td>
</tr>
<tr>
<td>PVC</td>
<td>10</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>ABS</td>
<td>10</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>HDPE</td>
<td>10</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>12</td>
</tr>
</tbody>
</table>

1) According to recognised standards for water supply on shore.
Table 12 Glassfibre reinforced epoxy ¹) and polyester pipes (GRP). Permissible pressures and temperature limits

<table>
<thead>
<tr>
<th>Minimum heat distortion temperature of resin, ISO 74 Method A</th>
<th>Nominal pressure ²) (bar)</th>
<th>Permissible working pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-50 to 30°C</td>
<td>40°C</td>
</tr>
<tr>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>135</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>16</td>
</tr>
</tbody>
</table>

1) Minimum heat distortion temperature 135°C
2) According to recognised standards for marine use.

3.8.8 Thermoplastic pipes for installation in external areas shall either be specifically approved for external use, or shall be protected against ultraviolet radiation.

3.8.9 Plastic pipes are normally made of electrically insulating materials and are as such not acceptable for service in gas hazardous areas. Special conductive qualities can be permitted if in accordance with the following principles:

— piping systems in or through gas hazardous areas carrying conductive fluids shall be electrically conductive on the outside
— piping systems in or through gas hazardous areas carrying non-conductive fluids, e.g. refined oil products and distillates, shall be electrically conductive on the inside and outside.

Where conductive piping is required, the resistance per unit length of pipe, fitting, etc. shall not exceed $10^5$ ohm/m, and the resistance to earth from any point in the piping system shall not exceed $10^6$ ohm.

3.8.10 The requirement for expansion elements shall be specially considered with respect to the large thermal expansion coefficient of the plastic materials.

**Guidance note:**
Glass-fibre reinforced epoxy and polyester pipes are considerably more exposed to damage from impact and local overloading than steel pipes. Handling, installation and inspection of such pipes should take care to avoid such damage.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.8.11 Where design loads incorporate a significant cyclic or fluctuating component, fatigue effects shall be considered in material selection and installation design.
3.8.12 Piping material shall be compatible with the fluid to be carried or in which it will be immersed (e.g. for other liquids or gases than the normal such as water and common hydrocarbons).

4 Pumps

4.1 General
Displacement pumps shall be provided with relief valves. The discharge from the relief valve of pumps transferring flammable fluids shall normally be led back to the suction side of the pump.

4.2 Hydrostatic tests

4.2.1 Pump housings, excluding those for pumps for transfer of stored crude oil, shall be hydrostatically tested to 1.5 times the maximum working pressure. The test pressure need not exceed the maximum working pressure by more than 70 bar.

4.2.2 Pumps for transfer of stored crude oil shall be tested to 1.3 times the maximum working pressure, and to a minimum of 14 bar. For centrifugal pumps the maximum working pressure shall be the maximum pressure head on the head-capacity curve. For displacement pumps the maximum working pressure shall not be less than the relief valve opening pressure.

4.2.3 The steam side of steam-driven pumps shall be hydraulically tested to 1.5 times the steam pressure. Hydrostatic testing of pump housings on submerged pumps will normally not be required.

4.3 Capacity tests

4.3.1 Pump capacities shall be checked with the pump running at design condition (rated speed and pressure head, viscosity, etc.).

Guidance note:
The capacity test need not be applied for pump designs where satisfactory tests have been previously performed and documented.

4.3.2 The pump characteristic (head-capacity curve) shall be determined for all centrifugal pumps having capacities less than 1000 m$^3$/h.

4.3.3 For centrifugal pumps having capacities equal to or greater than 1000 m$^3$/h, the pump characteristic for each pump shall be determined over a suitable range on each side of the pump design point.

4.3.4 Special survey arrangement for testing of pumps may be agreed upon.

5 Valves

5.1 Valve design

5.1.1 Design shall be documented for valves of new type or unconventional design and for valves of welded construction fitted on unit or installation hull side or bottom (e.g. ship hull, pontoon).

5.1.2 Pressure-temperature ratings for valves shall be in accordance with a recognised standard.
5.1.3 Screwed-on valve bonnets shall not be used for valves with nominal diameter exceeding 40 m in class I piping systems, for valves on ship's side and bottom and for valves in systems for flammable fluids. Bolted bonnets having bonnet secured to body by less than four bolts and/or having secured bonnet by U-bolts shall only be accepted for class III service.

5.1.4 Screwed-on valve bonnets shall be secured against loosening when the valve is operated.

5.1.5 Valves shall be closed by turning the hand wheel clockwise.

5.1.6 Indicators shall be provided to show the open and closed position of the valve, unless this can be observed in some other way.

5.1.7 Handles on cocks shall be removable only when the cocks are in closed position.

5.1.8 Welded necks of valve bodies shall be sufficiently long to ensure that the valves are not distorted as result of welding and subsequent heat treatment of the joints.

5.1.9 When the valves are designed for one way flow, the direction of flow shall be clearly and legible marked on the valve. The direction may be cast into the valve housing.

5.1.10 Suitable mechanical stops shall be provided on valves where the spindle is turned a part of a 360° turn between open and closed position. Manually operated butterfly valves, which are designed for throttling service, shall be equipped with a locking arrangement that holds the disc in any relevant position.

5.1.11 Non-integral seats or seat linings shall be locked in such a manner that they cannot become loose in service.

5.1.12 Valves with threaded end flanges or piping connections are subject for the restrictions given in [7].

5.2 Hydrostatic tests

5.2.1 All valve bodies shall be subject to a hydrostatic test, by the manufacturer, at a pressure equal to 1.5 times the nominal pressure (the nominal pressure is the maximum allowable working pressure at room temperature). The test pressure need not be more than 70 bar in excess of the nominal pressure. For valves fitted on unit or installation's side and bottom the test pressure shall not be less than 5 bar.

5.2.2 Butterfly valves fitted on unit or installation’s side or bottom shall also be hydrostatically tested at a pressure equal to 5 bar applied independently on each side of the closed disc.
6 Flexible hoses

6.1 General

6.1.1 A flexible hose assembly is a short length of metallic or non-metallic hose normally with prefabricated end fittings ready for installation.

6.1.2 Flexible hose assemblies may be accepted for use in fuel oil, lubricating, hydraulic and thermal oil systems, fresh water and sea water cooling systems, compressed air systems, bilge and ballast systems, refrigeration systems and class III steam systems. Flexible hoses in high pressure fuel oil injection systems are not accepted.

6.1.3 Flexible hoses may only be used when necessary to admit relative movements between machinery and fixed piping systems. The hoses shall be of type approved.

6.1.4 Flexible hoses intended for installation in piping systems for flammable media and sea water system where failure may result in flooding are to be of fire-resistant type. This is not applicable in cases where such hoses are installed on open decks, as defined in MODU Code 9.2.5.2 (10) and not used for fuel oil lines.

6.1.5 In fresh cooling water lines for diesel engines and compressors, flexible hoses without type approved couplings may be used provided each engine or compressor is arranged with an independent cooling system. Rubber hoses with internal textile reinforcement fitted by means of hose clamps may be accepted provided the hose is a short and reasonably straight length fitted between two metallic pipes with double hose clamps on each side.

6.1.6 Flexible hoses constructed of rubber materials and intended for use in bilge, ballast, compressed air, fuel oil, lubricating, hydraulic and thermal oil systems shall incorporate a closely woven integral wire braid or other suitable material reinforcement.
Flexible hoses of plastic materials for the same purposes, such as teflon of nylon, which are unable to be reinforced by incorporating closely woven integral wire braid, shall have suitable material reinforcement as far as practicable.
Where rubber or plastic material hoses shall be used in oil supply lines to burners, the hoses shall have external wire braid protection in addition to the reinforcement mentioned above. Flexible hoses for use in steam systems shall be of metallic construction.

6.1.7 For hoses of non-metallic materials, the suitability of the hose for its intended use shall be documented by means of drawings and specifications.

6.1.8 All hoses shall be hydrostatically tested at a hydrostatic pressure of 1.5 times the maximum working pressure.

6.2 Installation

6.2.1 Flexible hoses shall be installed so that they are accessible for inspection.

6.2.2 Flexible hoses shall be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery/equipment or systems.
6.2.3 Means of isolation shall be provided for flexible hoses used in systems for fuel oil, lubricating oil, seawater cooling and compressed air.

6.2.4 When used in systems conveying flammable fluids flexible hoses shall be shielded from hot surfaces and other sources of ignition.

7 Detachable pipe connections

7.1 Flange connections

7.1.1 Flanges with pressure-temperature ratings in accordance with a recognised international standard maybe accepted.

7.1.2 Examples of accepted flange connections for steel piping are shown in Figure 4. Typical applications of these types of connections are given Table 13 depending upon the class of piping, media, size, pressure and temperature. Other types of flange connections may be considered on a case by case basis.

7.1.3 For type D the pipe and flange shall be screwed with a tapered thread and the diameter of the screw portion of the pipe over the thread is not to be appreciably less than the outside diameter of the unthreaded pipe. For certain types of thread after the flange has been screwed hard home, the pipe shall be expanded into the flange. (See IACS UR P2.7.2.2)

![Figure 4 Types of pipe flanges](image-url)
Table 13 Type of flange connections

<table>
<thead>
<tr>
<th>Class of piping</th>
<th>Steam t (°C)</th>
<th>Typical flange application</th>
<th>Lubricating and fuel oil t (°C)</th>
<th>Typical flange application</th>
<th>Other media t (°C)</th>
<th>Typical flange application</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>&gt; 400</td>
<td>A</td>
<td>≤ 400</td>
<td>A - B</td>
<td>&gt; 400</td>
<td>A - B</td>
</tr>
<tr>
<td></td>
<td>≤ 400</td>
<td>A - B 1)</td>
<td></td>
<td>A - B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>&gt; 250</td>
<td>A - B - C</td>
<td>≤ 250</td>
<td>A - B - C - D - E</td>
<td>&gt; 250</td>
<td>A - B - C - D - E - F</td>
</tr>
<tr>
<td></td>
<td>≤ 250</td>
<td>A - B - C - D - E</td>
<td></td>
<td>A - B - C - D - E - F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>A - B - C - D - E</td>
<td></td>
<td>A - B - C - E</td>
<td>A - B - C - D - E - F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Type B or outer diameter < 150 mm only.

7.2 Pipe couplings other than flanges

7.2.1 Mechanical joints including pipe unions, compression couplings, slip-on joints and similar joints shall be type approved for the service conditions and the intended application. Examples of mechanical joints are shown in Table 14.

7.2.2 Slip-on joints shall not be used in pipelines in cargo holds, tanks, and other spaces which are not easily accessible. Application of these joints inside tanks may be permitted only for the same media that is in the tanks.

Mechanical joints, which in the event of damage could cause fire or flooding, shall not be used in piping sections directly connected to the sea openings or tanks containing flammable fluids.

The number of mechanical joints in oil systems shall be kept to a minimum. In general, flanged joints conforming to recognised standards shall be used.

(See IACS UR P2.7.4.11)

7.2.3 Piping, in which a mechanical joint is fitted, shall be adequately adjusted, aligned and supported. Supports or hangers shall not be used to force alignment of piping at the point of connection.

7.2.4 Unrestrained slip-on joints shall be used only in cases where compensation of lateral pipe deformation is necessary. The use of these joints as a means of pipe connection is not permitted.

7.2.5 Application of mechanical joints and their acceptable use for each service is indicated in Table 15. Dependence upon the class of piping and pipe dimensions is indicated in Table 16.

7.2.6 Slip-on threaded joints having pipe threads where pressure-tight joints are made on the threads with parallel or tapered threads, shall comply with requirements of a recognised national or international standard.

Slip-on threaded joints may be used for outside diameters as stated below except for piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.

Threaded joints in CO₂ systems shall be allowed only inside protected spaces and in CO₂ cylinder rooms.

Threaded joints for direct connectors of pipe lengths with tapered thread shall be allowed for:
— class I, outside diameter not more than 33.7 mm
— class II and class III, outside diameter not more than 60.3 mm.
Threaded joints with parallel thread shall be allowed for class III, outside diameter not more than 60.3 mm.

**Table 14 Examples of mechanical joints**

<table>
<thead>
<tr>
<th>Pipe Unions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welded and Brazed Types</td>
</tr>
</tbody>
</table>

![Welded and Brazed Types](image)

<table>
<thead>
<tr>
<th>Compression Coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swage Type</td>
</tr>
</tbody>
</table>

![Swage Type](image)

<table>
<thead>
<tr>
<th>Press Type</th>
</tr>
</thead>
</table>

![Press Type](image)

<table>
<thead>
<tr>
<th>Bite Type</th>
</tr>
</thead>
</table>

![Bite Type](image)
<table>
<thead>
<tr>
<th>Type</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flared Type</td>
<td>![Flared Type Diagram]</td>
</tr>
<tr>
<td>Grip Type</td>
<td>![Grip Type Diagram]</td>
</tr>
<tr>
<td>Machined Grooved Type</td>
<td>![Machined Grooved Type Diagram]</td>
</tr>
</tbody>
</table>

Slip-on Joints
The following table indicates systems where the various kinds of joints may be accepted. However, in all cases, acceptance of the joint type shall be subject to approval for the intended application, and subject to conditions of the approval and applicable rules.

**Table 15 Application of mechanical joints**

<table>
<thead>
<tr>
<th>Systems</th>
<th>Kind of connections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pipe unions</td>
</tr>
<tr>
<td><strong>Flammable fluids (flash point ≤ 60°C)</strong></td>
<td></td>
</tr>
<tr>
<td>1 Cargo oil lines ⁴)</td>
<td>+</td>
</tr>
<tr>
<td>2 Crude oil washing lines ⁴)</td>
<td>+</td>
</tr>
<tr>
<td>3 Vent lines ³)</td>
<td>+</td>
</tr>
<tr>
<td><strong>Inert gas</strong></td>
<td></td>
</tr>
<tr>
<td>4 Water seal effluent lines</td>
<td>+</td>
</tr>
<tr>
<td>5 Scrubber effluent lines</td>
<td>+</td>
</tr>
<tr>
<td>6 Main lines ²), ⁴)</td>
<td>+</td>
</tr>
<tr>
<td>7 Distributions lines ⁴)</td>
<td>+</td>
</tr>
<tr>
<td><strong>Flammable fluids (flash point &gt; 60°C)</strong></td>
<td></td>
</tr>
<tr>
<td>8 Cargo oil lines ⁴)</td>
<td>+</td>
</tr>
<tr>
<td>Systems</td>
<td>Kind of connections</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td>Pipe unions</td>
</tr>
<tr>
<td>9 Fuel oil lines 2),3)</td>
<td>+</td>
</tr>
<tr>
<td>10 Lubricating oil lines 2),3)</td>
<td>+</td>
</tr>
<tr>
<td>11 Hydraulic oil 2),3)</td>
<td>+</td>
</tr>
<tr>
<td>12 Thermal oil 2),3)</td>
<td>+</td>
</tr>
<tr>
<td><strong>Sea water</strong></td>
<td></td>
</tr>
<tr>
<td>13 Bilge lines 1)</td>
<td>+</td>
</tr>
<tr>
<td>14 Water filled fire extinguishing systems, e.g. sprinkler systems 3)</td>
<td>+</td>
</tr>
<tr>
<td>15 Non water filled fire extinguishing systems, e.g. foam, drencher systems 3)</td>
<td>+</td>
</tr>
<tr>
<td>16 Fire main (not permanently filled) 3)</td>
<td>+</td>
</tr>
<tr>
<td>17 Ballast system 1)</td>
<td>+</td>
</tr>
<tr>
<td>18 Cooling water system 1)</td>
<td>+</td>
</tr>
<tr>
<td>19 Tank cleaning services</td>
<td>+</td>
</tr>
<tr>
<td>20 Non-essential systems</td>
<td>+</td>
</tr>
<tr>
<td><strong>Fresh water</strong></td>
<td></td>
</tr>
<tr>
<td>21 Cooling water system 1)</td>
<td>+</td>
</tr>
<tr>
<td>22 Condensate return 1)</td>
<td>+</td>
</tr>
<tr>
<td>23 Non-essential system</td>
<td>+</td>
</tr>
<tr>
<td><strong>Sanitary/drain/scuppers</strong></td>
<td></td>
</tr>
<tr>
<td>24 Deck drains (internal) 6)</td>
<td>+</td>
</tr>
<tr>
<td>25 Sanitary drains</td>
<td>+</td>
</tr>
<tr>
<td>26 Scuppers and discharge (overboard)</td>
<td>+</td>
</tr>
<tr>
<td><strong>Sounding/vent</strong></td>
<td></td>
</tr>
<tr>
<td>27 Water tanks/Dry spaces</td>
<td>+</td>
</tr>
<tr>
<td>28 Oil tanks (f.p. &gt; 60°C) 2),3)</td>
<td>+</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td></td>
</tr>
<tr>
<td>29 Starting/Control air 1)</td>
<td>+</td>
</tr>
<tr>
<td>30 Service air (non-essential)</td>
<td>+</td>
</tr>
<tr>
<td>31 Brine</td>
<td>+</td>
</tr>
</tbody>
</table>

Chapter 2  Section 2

Marine and machinery systems and equipment

Table 16 Application of mechanical joints depending upon the class of piping

<table>
<thead>
<tr>
<th>Types of joints</th>
<th>Classes of piping systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class I</td>
</tr>
<tr>
<td>Pipe unions</td>
<td></td>
</tr>
<tr>
<td>Welded and brazed type</td>
<td>+ (OD ≤ 60.3 mm)</td>
</tr>
<tr>
<td>Compression couplings</td>
<td></td>
</tr>
<tr>
<td>Swage type</td>
<td>+</td>
</tr>
<tr>
<td>Bite type</td>
<td>+ (OD ≤ 60.3 mm)</td>
</tr>
<tr>
<td>Flared type</td>
<td>+ (OD ≤ 60.3 mm)</td>
</tr>
<tr>
<td>Press type</td>
<td>−</td>
</tr>
<tr>
<td>Slip-on joints</td>
<td></td>
</tr>
<tr>
<td>Machine grooved type</td>
<td>+</td>
</tr>
<tr>
<td>Grip type</td>
<td>−</td>
</tr>
<tr>
<td>Slip type</td>
<td>−</td>
</tr>
</tbody>
</table>

Abbreviations:
+ Application is allowed
– Application is not allowed

Footnotes:
1) Inside machinery spaces of category A - only approved fire resistant types.
2) Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.
3) Approved fire resistant types except in cases where such mechanical joints are installed on exposed open decks, as defined in MODU Code 9.2.5.2(10) and not used for fuel oil lines.
4) Only in pump rooms and open decks - only approved fire resistant types.
5) Slip type slip-on joints as shown in Table 14 may be used for pipes on deck with a design pressure of 10 bar or less.
6) Only above freeboard deck.

DNV GL AS
7.3 Expansion bellows

7.3.1 The use of expansion bellows shall be restricted as far as practicable.

7.3.2 Expansion bellows are subject to approval for their intended use. The bellows shall be so designed and installed that pulling or blowing out is prevented.

7.3.3 The pipeline in which an expansion bellow shall be fitted, shall be adequately adjusted, aligned and clamped. When found necessary, protection against mechanical damage of the expansion bellows may be required.

Guidance note:
Documentation and calculation of expansion bellows may be carried out in accordance with the EJMA standard.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

7.3.4 The positions of expansion bellows shall be clearly shown in the drawing of the piping systems.

8 Socket welded joints and slip-on sleeve welded joints

8.1 General

8.1.1 Socket welded joints and slip-on sleeve welded joints are allowed used for class I and II pipes with an outer diameter of 88.9 mm and less.

8.1.2 Socket welded joints and slip-on sleeve welded joints are allowed used for class III pipes.

8.1.3 Joint designs and socket dimensions in accordance with a recognised national or international standard will normally be adequate.

8.1.4 The use of socket welded joints and slip-on sleeve welded joints in stainless steel pipes should be carefully considered on a case by case basis.

8.1.5 Socket welded joints and slip-on sleeve welded joints shall not be used in overboard pipes where substantial thickness is required.
SECTION 3 PLATFORM PIPING SYSTEMS

1 General

1.1 Scope

1.1.1 The requirements of this section have been specifically aimed at mobile units and floating offshore installations of the self-elevating and column-stabilised design types, but may also be applied to other types of floating constructions as applicable.

1.1.2 Requirements for ship-shaped units are given in DNVGL-RU-SHIP Pt.4 Ch.6 Sec.4.

1.2 Location of piping and control systems

All parts of the piping and remote control systems shall normally be kept outside the damage penetration zones, which are defined in DNVGL-OS-C301.

Guidance note:
Exemptions may be considered in each case if the unit or installation can maintain the necessary ballasting capacity and acceptable stability conditions with damage to the structures and the pipes concerned, taking into account possible progressive flooding.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2 Ballast, bilge and drainage systems general

2.1 Basic requirements

2.1.1 An efficient system to empty all tanks and watertight compartments shall be provided.

Guidance note:
Void spaces without piping installations may be drained by portable equipment

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.2 The system required by [2.1.1] shall be so arranged that tanks and compartments can be effectively emptied through at least one suction even if the unit or installation has an inclination of 5° in any direction.

Guidance note:
In the case of dry compartments, the suctions required by [2.1.2], except where otherwise stated, may be branch bilge suctions, i.e. suctions connected to a main bilge line.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.3 The systems shall be so designed that not one single failure or maloperation of equipment can lead to uncontrolled liquid movement.

Unintentional filling of a single tank or a series of tanks shall not result in a critical condition of the unit or installation.

2.1.4 Means shall be provided to prevent release of oily water to sea.

2.2 Ballast systems

2.2.1 The unit or installation shall be provided with a ballast system so arranged that any tank can be de-ballasted or ballasted by either of at least two independently driven pumps or by controlled free flow.
2.2.2 Ballast pumps of centrifugal type shall be self-priming, by means of an automatic vacuum priming system.

2.3 Drainage of dry compartments below main deck

2.3.1 Dry compartments below main deck on self-elevating units and below the lowest continuous deck on column-stabilised units or installations, containing essential equipment for operation and safety, or providing essential buoyancy, shall have a permanently installed bilge or drainage system.

2.3.2 The compartments dealt with in [2.3.1] shall be emptied with at least two independently driven bilge pumps or similar equipment. One of the pumps shall be arranged solely for bilge pumping.

Guidance note:
Dry compartments other than machinery spaces and pump rooms may be arranged with drain pipes leading to a bilge well in the main bilge system.

2.3.3 Where an open drain pipe is carried through a watertight bulkhead or deck, it shall be fitted with an easily accessible self-closing valve at the bulkhead or deck, or a valve closable from above the damage water line. The valve shall have an indication for open or closed position.

2.3.4 Drainage or bilge lines from chain lockers shall not be connected to the bilge pumps required in [2.3.2].

2.3.5 Smaller void spaces, chainlockers on self-elevating units, etc. may be emptied by portable pumps or permanently installed pumps or ejectors. When emptying by portable pumps is intended, two units shall be available onboard.

Small compartments may be emptied by suitable hand pumps.

2.3.6 At least two branch bilge suctions shall be provided for emptying of rooms for essential machinery, e.g. pumps and propulsion machinery. In small compartments one bilge suction may be accepted.

2.3.7 An emergency bilge suction shall be arranged in addition to the suctions required in [2.3.6] for pump- and engine rooms. The suction shall be connected to the largest available and suitable pump other than the bilge pumps.

2.3.8 Drainage of hazardous areas should be given special consideration having regard to the risk of explosion.

(See MODU Code 4.9.7)

2.4 Drainage of dry compartments above main deck

Dry watertight compartments below damage water line shall be drained by one of the following methods:

— permanently installed bilge system
— draining directly to sea through easily accessible closable non-return valves
— draining to lower compartments with adequate bilge pumping capacity.

### 2.5 Pumping and piping arrangement

#### 2.5.1 All bilge pump connections to the bilge lines shall be fitted with screw-down non-return valves.

#### 2.5.2 The bilge pumps shall be so arranged that one can be used while the other is being overhauled.

#### 2.5.3 Centrifugal bilge pumps shall be located as low as possible in the unit or installation and be of the self-priming type.

*Guidance note:*

It is advised that at least one of the bilge pumps is of the reciprocating type. Large centrifugal pumps should preferably not be used as bilge pumps.

---end-of-guidance-note---

#### 2.5.4 Where pumps, necessary for propulsion, cooling of power generating plant or ballasting, are connected to a common suction or discharge chest or other piping, the arrangement shall be such that the functioning of any pump is not affected by other pumps in operation at the same time.

#### 2.5.5 The arrangement shall be such that no sea water can unintentionally enter dry compartments or pass from one compartment to another. The following requirements shall be complied with:

a) Two non-return valves in series shall be installed between sea or ballast system and bilge suctions in compartments.

b) For emergency bilge suctions one non-return valve between sea or ballast system and the suction will be acceptable.

c) Bilge distribution chest valves shall be screw-down non-return valves.

d) All bilge suctions not leading to a bilge distribution chest shall be fitted with screw-down non-return valves.

e) Bilge pipes through deep tanks, see [2.6.5].

#### 2.5.6 Remotely controlled valves in bilge suction lines shall be screw-down non-return valves or shut-off and non-return valves connected in series.

### 2.6 Bilge pipes

#### 2.6.1 The internal diameter of branch bilge suctions from each compartment shall not be less than given by the following formula, to the nearest 5 mm:

\[ d = 2.15 \sqrt{A} + 25 \]  \( \text{mm} \)

where A is wetted surface in \( \text{m}^2 \) of the compartment when the compartment is half way filled with water. The internal diameter of any branch bilge line is not to be less than 50 mm. For irregularly shaped compartments A will be specially considered.

#### 2.6.2 The cross-sectional area of the main bilge lines is not to be less than the combined area of the two largest branch suctions.

#### 2.6.3 The diameter of emergency bilge suction shall not be less than that of the suction side of the pump, but need not exceed 400 mm.
2.6.4 Bilge suction pipes shall, as far as practicable, not be carried through double bottom tanks. Where this cannot be avoided, the pipe wall thickness shall be as given in Sec.2 Table 7, column 4.

2.6.5 In deep tanks used for water ballast or fuel oil the bilge pipes shall be led through pipe tunnels or made of steel with a wall thickness according to Sec.2 Table 7. If possible they should consist of a single pipe length or be welded together. Expansion bends shall be fitted to the bilge pipes within the tanks, if needed. The open ends of these suction pipes in the dry compartments shall be provided with non-return valves.

2.6.6 The pipes shall be installed in convenient lengths in such a way that they may easily be dismantled for cleaning and repair.

2.7 Bilge pumps

2.7.1 Each pump unit may consist of one or more pumps connected to the main bilge line, provided their combined capacity is sufficiently large.

2.7.2 One of the bilge pumps may be a bilge ejector, provided that there is a separate pump delivering sufficient water for operating the ejector.

2.7.3 The capacity of each of the bilge pump units shall be sufficiently large to give the water, under ordinary working conditions, a velocity of at least 2 m/s through pipes of dimensions as given in [2.6.2].

2.7.4 Where the capacity of one pump is somewhat less than required, the deficiency may be made up for by the other pump. The capacity of the smaller pump, however, shall not be less than one third of the combined pumping capacity.

2.7.5 Pump capacity as a function of required pipe diameter for main bilge lines is given in Table 1.

Table 1 Pipe diameter and corresponding bilge pump capacity

<table>
<thead>
<tr>
<th>Bore of bilge pipe (mm)</th>
<th>Capacity of each pump (m³/hour)</th>
<th>Bore of bilge pipe (mm)</th>
<th>Capacity of each pump (m³/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>15</td>
<td>90</td>
<td>47</td>
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<td>55</td>
<td>18</td>
<td>95</td>
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<td>80</td>
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<td>120</td>
<td>83</td>
</tr>
<tr>
<td>85</td>
<td>42</td>
<td>125</td>
<td>90</td>
</tr>
</tbody>
</table>

The pump capacity Q in m³/hour may be determined from the formula:

\[ Q = \frac{5.75 \ d^2}{10^3} \]
\(d = \text{bore of bilge pipe in mm according to [2.6.2].}\)

2.7.6 Where large centrifugal pumps are arranged for suction, the pump characteristics together with calculations of the pressure losses in the pipe system shall be submitted for approval in those cases where the water velocity in the main bilge line will exceed 5 m/s. Arrangement plans of systems for air evacuation, cooling of bearings, etc. shall be documented.

2.8 Bilge wells, mud boxes, valves etc.

2.8.1 Bilge pipes for drainage of machinery spaces, pump rooms and shaft or pipe tunnels shall be led to mud boxes. The mud boxes shall have straight tail pipes to the bilges and shall be arranged for easy inspection and cleaning. Strums or rose boxes are not to be fitted to the lower end of these pipes or to emergency bilge suction.

2.8.2 Strums or rose boxes shall be fitted to the ends of bilge suction pipes in compartments intended for storage of supplies, and arranged for easy inspection and cleaning. The open area shall be at least twice the internal sectional area of the pipe. The diameter of the holes shall be approximately 10 mm.

2.8.3 The distance between the open ends of the bilge suction pipes and the bottom of the bilge or wells shall be adequate to allow a full flow of water and to facilitate cleaning.

2.8.4 Valves, cocks and mud boxes shall be located in readily accessible positions above or on the same level as the floor plates. Where this is not practicable, they may be placed immediately below, provided that the floor plates in question can be easily removed and are fitted with a name plate which indicates the presence of these fittings.

### 3 Ballast and bilge systems for column-stabilised units and installations

3.1 General

3.1.1 The general requirements in [2] shall be complied with, unless otherwise specified in this section.

3.1.2 The ballast system is to provide the capability to bring the unit or installation, while in an intact condition, from the maximum normal operating draught to a severe storm draught, within 3 hours. (See MODU Code 4.10.2)

**Guidance note:**
For units that maintain a constant draft (e.g. deep draft floaters or TLP's) the ballast system should have sufficient capacity to restore the unit after a damage scenario (e.g. loss of tendon, compartment damage) to an acceptable design condition (compensated load case) within a reasonable period of time.

---e-n-d-o-f-g-u-i-d-a-n-c-e---n-o-t-e---

3.1.3 Ballast Water Management Systems
Units with ballast water treatment systems installed in order for ships to meet the requirements of the Ballast Water Management Convention shall follow the requirements of the DNVGL-RU-SHIP Pt.6 Ch.7 Sec.1.
3.2 Remote control and monitoring

3.2.1 A central ballast control station shall be provided. It shall be located above the damage waterline and in a space not within the assumed extent of damage referred to in DNVGL OS C301 and adequately protected from weather. It shall be provided with the following control and indicating systems where applicable:

— bilge and ballast pump control system
— pump status-indicating system
— valve control system
— valve position-indicating system
— tank level indicating system
— draught indicating system
— heel and trim indicators
— power availability indicating system (main and emergency)
— hydraulic or pneumatic pressure-indicating system
— monitoring systems, e.g. machinery alarm, fire and gas detection system etc.

(See MODU Code 4.10.10)

Interpretation:

A dedicated central ballast control station is not required for units that maintain a constant draft and have limited ballasting operations. Ballast controls may be placed within a multipurpose central control station.

---end---of---interpretation---

3.2.2 In addition to remote control of the ballast pumps and valves from the central ballast control station, all ballast pumps and valves shall be fitted with independent local control operable in the event of remote control failure. The independent local control of each ballast pump and of its associated ballast tank valves shall be in the same location.

(MODU Code 4.10.11)

3.2.3 The control and indicating systems required in [3.2.1] and [3.2.2] shall function independently of each other, or have sufficient redundancy, such that a failure in one system does not jeopardize the operation of any of the other systems.

(MODU Code 4.10.12)

3.2.4 The valves in the ballast system shall be of the self-closing type or operated by a system with stored energy for closing of the valves during emergency conditions.

3.2.5 The remote control system for ballast and bilge valves shall be arranged with power supply from both main- and emergency switchboards.

3.2.6 Short circuit of one electrically remote operated valve shall not inhibit the function of other valves.

Interpretation:

Separate fusing in each valve control circuit is considered meeting the requirement.

---end---of---interpretation---

3.2.7 A means to indicate whether a valve is open or closed shall be provided at each location from which the valve can be controlled. The indicators shall rely on movement of the valve spindle, or be otherwise arranged with equivalent reliability.
3.2.8
Means shall be provided at the central ballast control station to isolate or disconnect the ballast pump control and ballast valve control systems from their sources of electrical, pneumatic or hydraulic power.
(See MODU Code 4.10.18)

3.3 Ballast system

3.3.1 The ballast system shall be capable of operating after the damage condition as specified in DNVGL-OS-C301 Ch.2 Sec.1 [5.9] and have capability of restoring the unit or installation to a level trim and safe draught condition without taking additional ballast and with any one pump inoperable. Counter-flooding may be considered as an operational procedure.
(See Modu Code 4.10.4)

Interpretation:
Counter-flooding is not to be considered as a means to improve the suction head available to the ballast pumps when considering the operability of the ballast system after the damage specified in DNVGL-OS-C301 Ch.2 Sec.1 [5.9].

---e-n-d---o-f---i-n-t-e-r-p-r-e-t-a-t-i-o-n---

Guidance note:
For constant draft, floating units (e.g. TLP's) a passive ballast system with no direct connection to the sea below the damage waterline may be accepted.
The passive ballast system should be provided with at least two permanently connected prime movers that are to be considered part of the ballast system.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.2 The sea water inlets to the ballast system shall be separated from other systems. A common ballast and sea water cooling system may be accepted upon special consideration.

3.3.3 The ballast system shall be arranged and operated so as to prevent inadvertent transfer of ballast water from one tank or hull to another, which could result in moment shifts leading to excessive angles of heel or trim.
(See MODU Code 4.10.5)

3.3.4 For filling of ballast system by free flooding, the following criteria apply in connection with tank filling arrangement:
— all pump filling connections to the tank are physically disconnected (blank installed)
— filling directly down the venting pipe is not permitted in normal operational conditions
— the method of hydrostatic testing shall be in accordance with DNVGL-OS-C401 Ch.2 Sec.4 [3.1].

3.3.5 For filling with pumps with tank level alarms installed, the following criteria normally apply in connection with tank filling arrangement:
— the system with the tank level alarms is installed as the only means of ballasting the tanks; direct filling above a given level \( h_{op} \) see e.g. DNVGL-OS-C103 is not to be physically possible
— in order to avoid dynamic load effects from filling, the following shall be installed:
— high level alarms
— high, high level alarms
— auto-pump cut off at high, high level or ESD closure of inlet valve
— filling directly down the venting pipe is not permitted in normal operational conditions
— the method of hydrostatic testing shall be in accordance with DNVGL-OS-C401 Ch.2 Sec.4 [3.1].

3.4 Bilge system

3.4.1 The bilge system shall be so arranged that essential rooms in lower hulls, e.g. pump rooms, can be emptied even in flooded condition. The control and position-indication systems for the bilge valves shall be designed to operate even if the equipment should become submerged.

3.4.2 Propulsion rooms and pump rooms in lower hulls which are normally unattended, shall be provided with two independent high level bilge alarms.

   Guidance note:
   For units that maintain a constant draft (e.g. deep draft floaters and TLP’s), this also applies to spaces which have an increased potential for flooding e.g. through sea chest or cooling system of machineries.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.4.3 Spaces fitted with automatic sprinkler systems shall be provided with drainage arrangements with a capacity at least equal to the sprinkler system assuming all nozzles in the space are in operation.

4 Ballast and bilge systems for self-elevating units and installations

4.1 General

4.1.1 The general requirements in [2] shall be complied with, unless otherwise specified in this section.

4.1.2 The unit or installation shall be provided with means for emptying of engine rooms and watertight compartments and tanks which provide essential buoyancy.

4.1.3 Units with ballast water treatment systems installed in order for ships to meet the requirements of the Ballast Water Management Convention shall follow the requirements of the DNVGL-RU-SHIP Pt.6 Ch.7 Sec.1.

4.2 Pre-load system

Alternative methods for drainage of pre-load tanks, e.g. by means of bottom valves, may be accepted upon special consideration.

4.3 Bilge system

4.3.1 The unit or installation shall be equipped with 100% redundancy in bilge pumping system and means for draining all compartments and watertight sections.

Compartments containing liquids such as cooling water, oil fuel or stored produced liquid shall be connected to separate dedicated pumping systems.

4.3.2 A graphic panel showing all components and arrangements of bilge and drainage system shall be suitably positioned at the bilge pumping station.

4.3.3 Spaces fitted with automatic sprinkler or water spray systems shall be provided with drainage arrangements with a capacity at least equal to the sprinkler system assuming all nozzles in the space are in operation.
5 Air, overflow and sounding pipes

5.1 Arrangement of air pipes

5.1.1 Air pipes shall be fitted to all tanks, cofferdams and pipe tunnels. For small dry compartments without piping installations the requirement for fitting air pipes may be waived.

5.1.2 Air pipes shall not be fitted with valves that may impair the venting function.

Tank air pipes shall be placed at the highest part of the tank and as far away as possible from the filling pipes.

Where the tank top is unusual or of irregular profile or of great length, the number and positions of the air pipes shall be decided in each case. For tanks with width exceeding half of the unit's or installation's beam, air pipes on each side may be required. Pipe tunnels of great length shall be fitted with air pipes in the fore and after ends.

5.1.3 Air pipes from tanks which can be filled from the sea and from sea chests shall be carried up to above the freeboard deck.

5.1.4 Air pipes from fuel oil tanks, double bottom tanks, cofferdams and all other tanks which can be pumped up and to pipe tunnels, shall be carried above the freeboard deck and led to open air.

Air pipes from lubricating oil storage tanks may terminate in the machinery space, provided that the open ends are so located that issuing oil cannot come into contact with electrical equipment or heated surfaces.

Air pipes from fuel oil daily service tanks shall terminate at positions sufficiently high to avoid the possibility of ingress of seawater.

The height is at least to satisfy the requirements in the International Convention on Load Lines (ICLL) for ventilation openings not required to be fitted with closing arrangements (see DNVGL-OS-C301). The air pipes shall be so located that risk of damage from sea or loose objects is avoided.

5.1.5 Air pipes from fuel oil draining tanks with a volume less than 2 m³ and which cannot be pumped up, may terminate in the engine room.

5.1.6 For height and wall thickness of air pipes above deck, see DNVGL-OS-C301.

5.1.7 The ends of the air pipes shall be so designed or so located that ingress of water is prevented. Automatic vent heads with ball floats or similar devices shall be of approved design.

5.1.8 Tanks where anodes for cathodic protection are installed shall have air pipes fitted forward and aft.

Alternatively a single air pipe may be accepted if it is fitted with fine-meshed wire gauze easily removable for cleaning or renewal. The wire gauze shall be placed near to the outlet, and the area of the pipe end opening shall be enlarged to twice the pipe cross section. The open ends shall be situated in positions where no danger will occur as a consequence of escaping oil vapour or gas.

Guidance note:

In cold climatic conditions the possibility of freezing of vents should be taken into account.

5.1.9 Where only one air pipe is fitted, it is not to be used as a filling pipe.

5.1.10 All air pipes shall be clearly marked at the upper end.
5.1.11 Air pipes shall be self draining under normal conditions of trim.

5.1.12 Air pipes shall not be used as primary means for sounding.

5.1.13 Air pipes for tanks containing heated fuel shall comply with Sec.4 [4.1].

5.2 Air pipes, sectional area

5.2.1 For tanks which can be pumped up and for which overflow pipes are not arranged, the sectional area of air pipes shall be dimensioned such that the structure is able to withstand the pressure when the tank is over pumped with the largest available pump. Pressure drops in air pipes for water overflow shall be documented by calculations. The calculations shall verify that the dynamic pressure increase during water overflow does not exceed the assumed pressure drop used for the structural strength calculations of the tank, as specified in DNVGL-OS-C101 Ch.2 Sec.2. Alternatively, arrangements for prevention of over filling of tanks may be accepted. See also [3.3.5]. The sectional area of the air pipes shall in no case to be taken less than 125% of the sectional area of the filling pipe.

Guidance note:
Automatic stop of ballast pumps or automatic closing of valve in the ballast filling line may be accepted as arrangement for prevention of over pumping of tanks. Such means should be activated by a remote level gauging system or equivalent. In addition an independent visual and audible high level or high-pressure alarm is required. The alarm should be activated prior to stop of pumps or closing of valve. Arrangements for functional testing of the automatic stop or closing and alarm systems should be provided. See also [3.3.5].

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.2.2 For tanks which can be filled from installations outside the unit or installation (e.g. bunker fuel tanks) and not fitted with overflow pipes, the sectional area of air pipes shall not be less than 125% of the sectional area of the filling pipe. The maximum allowable pump capacity shall be stated on signboards at the filling pipe connection.

5.2.3 Air pipes from ballast tanks filled by free flooding only, may have less air pipe area, but in no cases less than 25% of the sectional area of filling pipe.

5.2.4 Air pipes are to have an internal diameter not less than 50 mm.

5.2.5 Pipe tunnels shall be fitted with an air pipe with an internal diameter not less than 75 mm.

5.3 Overflow pipes, arrangement

5.3.1 The requirements in [5.3.2] to [5.4] are applicable to any overflow system when fitted.

5.3.2 The overflow tanks shall have sufficient capacity for an overflow of 10 minutes at the normal rate of filling.

5.3.3 Where a storage tank is used for overflow purposes a signboard shall be fitted to signify that sufficient volume for overflow is ensured. The use of a fuel storage tank as overflow also requires installation of a high level alarm and an air pipe with 1.25 times the cross-sectional area of the main bunkering line.
5.3.4 The overflow system shall be fitted with an alarm device or a sight glass, easily visible from the place where the transfer pump can be stopped.

5.3.5 The overflow system shall be so arranged that water from the sea cannot enter through the overflow main line into other tanks in case of any tanks being damaged.

Guidance note:
This requirement applies if any fuel tank or overflow tank connected to a common overflow line or air vent tank is bounded by bottom or side plating below the waterline.
In such cases the common overflow line or air vent tank should be located higher than the deepest waterline, alternatively individual tank overflow lines should be arranged with loops extending above the waterline.
Routing of the pipe lines in the overflow system should take account of the deepest waterline derived from the damage stability calculations. The deepest waterline in this context should be taken from the cases where any tank connected to the system are damaged and should correspond to the equilibrium angle after damage + the required range of positive stability (residual stability).

---end---of---g-u-i-d-a-n-c-e---n-o-t-e---

5.3.6 The overflow pipes shall be self draining under normal conditions of trim and ambient temperature.

5.4 Overflow pipes, sectional area
The sectional area of overflow pipes shall be dimensioned in accordance with the requirement in [5.2.1].

5.5 Sounding arrangements

5.5.1 Indication of liquid level in the ballast tanks, draught and inclination of the unit or installation shall be provided for safe operation of the ballasting system.

5.5.2 For column-stabilised units or installations the indications in [5.3.1] shall be provided in the centralised control room.

5.5.3 Remote sounding systems shall be designed to withstand possible overload, e.g. from overfilling the tanks.
The number and position of measuring points shall be arranged to correct for the influence of inclination, as far as possible.

5.5.4 All tanks, cofferdams and pipe tunnels shall be provided with sounding pipes or other approved means for ascertaining the level of liquid in the tanks. Spaces which are not always accessible, shall be provided with sounding pipes.

5.5.5 The sounding pipes shall be readily accessible at any time and clearly marked.
Sounding pipes are normally to be led to the freeboard deck. Sounding pipes from fuel oil tanks, lubricating oil tanks and other tanks containing flammable liquids, and which can be pumped up, shall be led to the open air (except as provided for in [5.5.6]).
Sounding pipes to tanks containing liquids which have a flash point below 60°C (closed cup), shall always be led to the open air. Sounding rods of such tanks shall be of spark proof material and no gauge glasses shall be fitted to these tanks if located in machinery spaces.
The sounding pipes shall be fitted with efficient closing appliances.
5.5.6 Readily accessible short sounding pipes may be fitted to the top of tanks in machinery spaces and shaft tunnels. If the tanks contain fuel oil or other flammable liquids the following conditions shall be met:

a) A closed type level gauging system is fitted.
b) The sounding pipes terminate in safe distance from ignition hazards. If not, other arrangements shall be made to prevent oil from coming into contact with a source of ignition.
c) The terminations of sounding pipes shall be fitted with self-closing cocks having cylindrical plugs with weight-loaded levers permanently attached.
d) Small test cocks are fitted below the self-closing cocks.

For fuel oil tanks above double bottom short sounding pipes may be permitted on the same conditions provided that in addition the tanks are fitted with an approved oil level gauge.

Short sounding pipes to tanks not intended for oil shall be fitted with a screw cap attached by chain to the pipe or with shutoff cocks.

5.5.7 Striking plates with a minimum thickness of 15 mm or a similar arrangement shall be fitted under sounding pipes in order to absorb the impact of the sounding rod.

Where sounding pipes terminate in a bend, the bend shall be adequately fastened and supported and of sufficient thickness for taking the wear from the sounding rod. Such sounding pipes, however, are not to be used for deep tanks, unless they are situated within closed cofferdams or within tanks containing similar liquids.

5.5.8 Means shall be provided for sounding and draining of water-tight structural members such as bracings of column-stabilised units/installations.

5.5.9 Watertight compartments through which sea water pipes are routed (e.g. cooling water or fire main) shall, in addition to the drainage system required by [2.1.1] and [2.1.2], have leak detection and remotely controlled drainage valves.

The consequences of full pipe rupture and flooding of the compartment shall be considered in the stability documentation.

Guidance note:
Operational procedures specifying time to pump trip or opening/closing of valves may be taken into consideration.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.6 Sounding pipes, sectional area

5.6.1 The internal diameter of sounding pipes shall not be less than 38 mm.

5.6.2 Where a sounding pipe exceeds 20 m in length, the internal diameter shall not be less than 50 mm.
(See IACS UR D9.8.1)

5.7 Other level indicating devices

5.7.1 Other level indicating devices of approved type may be installed in lieu of sounding pipes, provided adequate means to prevent release of oil in case of failure or overfilling are fitted.

5.7.2 If flat glass type gauge glasses or magnetic level indicators are installed as a means of level indication for tanks containing flammable fluids, they shall be fitted with a self-closing valve at each end, and shall be protected against mechanical damage.
5.7.3 Other oil level indicating devices and level switches, which penetrate below the tank top, may be used, provided they are contained in steel enclosures, or other enclosures, that shall be designed to withstand a fire without being destroyed.

5.7.4 Open sounding system shall not be allowed for oil fuel tanks which can be heated to above 50°C.

5.7.5 Remote sounding system of approved type may replace ordinary sounding pipes or gauges as follows:
1) For tanks easily accessible for checking of level through for example manholes, or if the remote sensor can be easily replaced without entering the tank, one remote sounding system may be accepted.
2) For tanks not always accessible for checking of level, two independent remote sounding systems are required. In the case of remote sounding based on the air-bubble principle, two air-bubble lines per tank may be accepted provided sufficient redundancy in the central unit is provided.

6 Storage and transfer systems for liquids with flashpoint below 60°C (e.g. helicopter fuel)

6.1 General
Tanks and pipe systems for such liquids shall be in accordance with relevant requirements given elsewhere in this standard.

6.2 Arrangement

6.2.1 Storage tanks shall be located as far as practicable from the accommodation area, escape ways, and embarkation stations for evacuation.

6.2.2 Tanks and associated equipment should be protected from physical damage (e.g. from dropped objects where this is possible) and from a fire in an adjacent area.

6.2.3 Rooms where tanks and equipment for handling of such liquids are located, shall be regarded as hazardous areas, zone 2. The rooms shall be effectively ventilated.

   Guidance note:
   Gauge glasses with self-closing cocks for level indication can be accepted for such tanks located outside of engine rooms or other safe areas.

6.2.4 The air pipes to the tanks shall be provided with pressure/vacuum (P/V) relief valves. The valves shall be of sufficient capacity to relieve the over/under pressure which occurs during filling or emptying at maximum rate.

6.2.5 For tanks on open deck, permanently installed and arranged for filling, the area 1.5 m from the P/V valves shall be regarded as hazardous area zone 2.
For transportable tanks (i.e. not refilled onboard but replaced by full tanks) where P/V valves are for breathing purposes only (small gas quantities) no hazardous area need to be designated around the P/V valves.

6.2.6 The fuel storage area shall be arranged with means by which spillage can be collected and drained to a safe location.
6.2.7 Storage tank pumps shall be provided with means which permit shutdown from a safe remote location in the event of a fire. Where a gravity fed fuelling system is installed, equivalent closing arrangements shall be provided.

6.2.8 Fuel pumping shall incorporate a device which will prevent over pressurisation of the delivery filling hose.

6.2.9 In order to ensure proper fuel cleanliness corrosion resistant material, lining or coating shall be provided in tanks and piping systems.

6.2.10 Fuel transfer system for helicopter refuelling shall be earthed.
SECTION 4 MACHINERY PIPING SYSTEMS

1 General

1.1 Scope

1.1.1 The requirements of this section have been specifically aimed at mobile units and floating offshore installations of the self-elevating and column-stabilised design types, but may also be applied to other types of floating constructions as applicable.

1.1.2 Requirements for ship-shaped units are given in DNVGL-RU-SHIP Pt.4 Ch.6 Sec.5.

1.2 Redundancy and capacity

Redundancy shall be arranged as specified in Sec.1 [2.3]. Redundancy capacity of components shall be as specified in the requirements for the different systems.

Applied to piping systems this implies that more than one pump unit shall be installed when failure of such a unit will result in loss of a main function.

The capacity shall normally be sufficient to cover demands at maximum continuous load on the main function when any pump unit is out of service.

2 Cooling systems

2.1 General

2.1.1 Centrifugal sea-water cooling pumps shall be installed as low as possible in the unit or installation or other means shall be provided to prevent, as far as practicable, that the pumps lose water in a seaway.

2.1.2 Shut-off valves shall be provided at the inlet and outlet of all heat exchangers.

2.1.3 Every heat exchanger and cooler shall be provided with a vent and a drain.

2.1.4 For heat exchangers attached to smaller engines (or other small installations), the requirements of [2.1.2] and [2.1.3] may be dispensed with, provided that the engine is fitted with such shut-off valves and drains.

2.1.5 When generator prime movers are connected to a common water cooling system, the arrangement shall be such that the supply of cooling water to the prime movers will not be affected by damage and leakage in other parts of the system.

Guidance note:

It is recommended that water cooling for generator prime movers is separated from water cooling systems for other purposes.

2.1.6 Cooling systems in self-elevating units or installations shall be so arranged that the supply of cooling water to the generator prime movers will not be affected, even if the fire pumps are in operation, during raising and lowering of the installation. In such events the cooling water may be supplied from a storage tank.
2.1.7 If cooling water is used for heating of oil, the system shall be arranged to avoid contamination of the cooling water. For this purpose the heating coils shall be located on the pressure side of the cooling pumps. Alternatively a primary and secondary system arrangement may be used. In the case of direct heating the heating coils shall be all welded with no detachable connections where mixing of oil and water may occur.

2.2 Sea inlets for cooling water pumps

2.2.1 Sea-water cooling systems for the machinery shall be connected to at least two cooling water inlets.

2.2.2 Strums shall be fitted to all sea chest openings in the shell plating. The total area of the strum holes shall be at least twice the total flow area in the sea water inlet valves.

2.2.3 Where sea water is used for cooling the main engines or auxiliary engines, the cooling water and suction lines shall be provided with strainers which can be cleaned without interrupting the cooling water supply.

2.2.4 Regarding sea chest arrangements for vessels having additional class notations for navigation in ice, see DNVGL-OS-C103 App.E, DNVGL-OS-C201 App.E or DNVGL-RU-SHIP Pt.6 Ch.6 Sec.1 as applicable.

2.2.5 Regarding sea inlets see Sec.1 [1.8].

3 Lubricating oil system

3.1 General

3.1.1 Lubricating oil systems shall be separated from other systems. This requirement does not apply to hydraulic governing and manoeuvring systems for main and auxiliary engines.

3.1.2 Lubricating oil drain pipes from the engine sump to the drain tank shall be submerged at their outlet ends.

3.2 Lubricating oil pre-treatment arrangement

3.2.1 For systems where the lubricating oil circulates under pressure, efficient filtering shall be provided.

3.2.2 For non-redundant units, it shall be possible to clean the filters without interrupting the oil supply. If automatic cleaning filters are used, means shall be provided to ensure the oil supply in case of failure in the automatic cleaning and change over system.

Guidance note:
A manual back-wash function for emergency purpose is accepted as a means to ensure oil supply when automatic back-wash type filter is installed.

---end---of---guide---note---

3.2.3 For diesel engines burning residual oil fuel, cleaning of the lubrication oil by means of purifiers shall be arranged. These means are additional to the filters required in [3.2.1].
3.3 Lubricating oil supply
Each engine or turbine shall be supplied with at least one lubricating oil pump of sufficient capacity for the maximum output of the engine.

3.4 Remote controlled shut-off arrangement for lubricating oil tanks
Valves on lubricating oil tanks shall be arranged for remote quick-acting shut-off as outlined in [4.5.1] if all conditions below are in place:
— the tanks are situated in machinery spaces above the double bottom
— the valves are open during normal service
— the valves are located below the top of the tank or overflow outlet.

Guidance note:
Based on case by case consideration, this requirement may be waived for small tanks with volume less than 0.5m³, and tanks for which an unintended closing of the valves may result in loss of main function as specified in Ch.2 Sec.1 [2.3].

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4 Fuel oil system

4.1 Flash point of fuel oil

4.1.1 Oil fuels with a flash point of less than 60°C (closed cup) are not permitted, except for the following:
— units or installations certified for restricted service within areas having climate ensuring that ambient temperatures of spaces where such fuel oil is stored will not rise to temperatures within 10°C below the flash point of the fuel, may use fuel oil with flash point below 60°C but not less than 43°C.
— installation specially approved for the use of crude oil as fuel.

The use of gas as fuel is permitted as given in [12].

4.1.2 Heating of oil fuel in storage tanks shall be limited to a temperature 10°C below the flash point of the fuel except that for heated tanks in the supply system when arranged in compliance with the following:
— temperature of the vapour at the outlet of the air pipes shall be below 60°C when the outlet is within 3 m from a source of ignition
— the vent pipes are fitted with flame screens meeting the requirements of IMO’s Standards for Devices for Preventing Passage of Flames into Cargo Tanks
— no openings from the vapour space of the fuel tanks shall have outlet into machinery spaces
— enclosed spaces shall not be located directly over such fuel tanks, except for well-ventilated cofferdams
— electrical equipment shall not be fitted in the vapour space of the tanks, unless it is certified suitable for the area classification within the tank.

4.1.3 Liquids for specific purposes and whose flash point is lower than 43°C should preferably be stored outside the machinery space. If tanks for such liquids are installed in the engine room, this shall be specifically evaluated and documented.

4.2 Fuel oil tanks

4.2.1 Two fuel oil service tanks for each type of fuel used on board necessary for propulsion and vital systems or equivalent arrangements shall be provided. Each tank shall have a capacity sufficient for continuous rating of the propulsion plant and normal operating load at sea of the generator plant for a period of not less than 8 hours.
4.2.2 Fuel oil tanks shall be separated from fresh water tanks by means of cofferdams.

4.2.3 Where fuel oil tanks are situated near to boilers or other hot surfaces, the tanks shall be well insulated. In order to keep the oil temperature well below the flash point, care shall be taken that the free air circulation is not impeded.

4.2.4 The plate thickness in free standing fuel oil tanks shall not be less than 5 mm. For very small tanks the plate thickness may be reduced to 3 mm. Sides and bottom of the tanks shall be well stiffened. Large tanks shall be fitted with wash bulkheads.

4.2.5 Outlets for fuel oil centrifuges, if fitted, shall be taken from the lowest point of the tank bottom.

4.3 Fuel oil piping

4.3.1 Piping conveying flammable liquids under pressure in the engine room and boiler room shall be laid in well lit places, in order that the piping can be kept under observation.

4.3.2 All detachable pipe connections and valves in oil fuel pressure piping shall be at a safe distance from boilers, exhaust pipes or other heated surfaces and electrical appliances.

4.3.3 The number of detachable pipe connections shall be limited to those which are necessary for mounting and dismantling.

4.3.4 Fuel oil pipes shall not be routed through fresh water, lubricating oil or thermal oil.

4.3.5 The arrangement of piping and valves shall be such that oil cannot enter tanks not intended for this purpose.

4.3.6 The design pressure for fuel oil systems with a working pressure above 7 bar and a working temperature above 60°C shall be minimum 14 bar. Other fuel systems shall have a minimum design pressure of 3 bar. 
(See IACS UR P1.2.7)

4.4 Arrangement of valves, cocks and fittings

4.4.1 Every fuel oil inlet or outlet pipe from any fuel oil tank, that would allow fuel oil to escape from the tank if damaged, shall be fitted with a shut-off or non-return valve directly on the tank. For a tank situated above the double bottom, the valve shall be secured to the tank itself.

Guidance note: Short distance pieces of rigid construction are acceptable in places where valves are required to be fitted directly on tanks.

4.4.2 All valves and cocks on oil tanks shall be mounted and protected in such a way that they cannot be damaged as the result of an accident. The positioning of valves shall be such that any possible leakage will not lead to oil spray on boilers, exhaust pipes or other hot surfaces of the machinery, or on electric motors and appliances.
4.4.3 In multi-engine installations, which are supplied from the same fuel source, means of isolating the fuel supply and spill piping to individual engines shall be provided. The means of isolation shall not affect the operation of the other engines, and shall be operable from a position not rendered inaccessible by a fire on any of the engines.

4.4.4 All valves in the fuel oil system shall be controllable from positions above the floor plates.

4.4.5 For requirements to level indication devices see Sec.3 [5].

4.5 Remotely controlled shut-off arrangement for fuel oil tanks

4.5.1 Oil fuel pipes, which, if damaged, would allow oil to escape from a storage, settling or daily service tank having a capacity of 0.5 m$^3$ and above and situated above the double bottom, shall be fitted with a cock or valve directly on the tank capable of being closed from a safe position outside the space concerned.

4.5.2 In machinery spaces, fuel oil valves on tanks shall be arranged as "quick-acting shut-off valves" with remote operation. The operation shall be carried out from a central position outside the space itself and at a safe distance from skylights and other openings to engine and boiler rooms.

**Guidance note:**
A central position is normally the same location where possible CO2 release and shut down of FO pumps and ventilation is arranged.

---end of guidance note---

**Guidance note:**
This is not applicable for valves closed during normal service, valves on double bottom tanks or valves on tanks less than 0.5 m$^3$.

---end of guidance note---

**Guidance note:**
For valves on filling lines connected below the liquid level, remote shut-off may be omitted if non-return valves are used.

---end of guidance note---

4.5.3 The controls for remote shut-off for emergency generator and emergency fire pump shall be located separately from the controls of the other valves in order to avoid erroneous operation.

4.5.4 Every oil fuel pipe, which is led into the engine room from a tank situated above the double bottom outside this space, shall also be fitted with a quick-acting shut-off valve in the engine room close to the bulkhead. This is not applicable where the valve on the tank is arranged for remote shut-off.

4.5.5 The arrangement shall be such that paint, corrosion etc. will not impair the efficiency of the remote operation of the valves.

4.5.6 Hydraulic or pneumatic systems shall not be used as means for keeping quick-acting shut-off valves in open position.

4.5.7 The means used to operate the quick acting shut-off valves shall be independent of any power sources located in the same space as the valves. For a pneumatically operated system, the air supply may be from a source located within the same space as the valves provided that an air receiver complying with the following is located outside the space:

— sufficient capacity to close all connected valves twice
— fitted with low air pressure alarm
— fitted with a non-return valve adjacent to the air receiver in the air supply line.
Materials readily rendered ineffective by heat shall not be used in the construction of the valves or the closure mechanism.

4.6 Fuel oil pre-heaters
For requirements for electric oil heaters, see DNVGL-OS-D201.

4.7 Fuel oil pre-treatment arrangement

4.7.1 Filters shall be fitted in the supply lines to the main and auxiliary machinery. These shall be arranged in such a way that they can be cleaned without interrupting the supply of fuel oil.

**Guidance note:**
For auxiliary engines one single fuel oil filter for each engine may be accepted.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.7.2 Fuel supply for diesel engines burning residual oil fuel (heavy fuel) or mixtures containing such oils shall be provided with suitable means for removal of harmful contaminants. These means are additional to the filters required in [4.7.1] If centrifuges are used for the above purpose the arrangement shall have adequate built-in redundancy.

4.8 Drip trays

4.8.1 All oil tanks in machinery spaces shall be equipped with drip trays of sufficient capacity and height for collecting any leakage of oil which may occur from valves, fittings etc. The drip trays shall be drained to a closed waste tank not forming part of an overflow system.

**Guidance note:**
For drip trays intended for small leakages and located far away from the nearest drain tank, other solutions may be considered

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.8.2 Precautions shall be taken against overflow of oil from the lowest situated drip trays. Drain pipes led to double bottom tanks shall be provided with means for prevention of back flow.

4.8.3 Drip trays shall be fitted under those parts of the fuel oil system which are often opened up for cleaning such as burners, purifiers, filters, etc.

4.9 Oil filters
Duplex filters used in systems for flammable liquids shall be arranged with means for preventing unintended opening of a filter under pressure.

4.10 Various requirements

4.10.1 Settling tanks and daily service tanks shall be fitted with means for draining of water from the bottom of the tanks.

4.10.2 Open drains for removing water from oil tanks shall be fitted with self-closing valves or cocks, and means shall be provided for collecting all waste oil in closed tanks.
4.10.3 The oil burners shall be so arranged that they cannot be withdrawn unless the oil supply to the burners is cut off.

4.10.4 For auxiliary boilers where the installation of two separate burner units is impossible, the use of one unit may be accepted on the condition that necessary spare parts are provided.

4.10.5 For vessels with periodically unmanned machinery machinery, flow meters in fuel oil lines shall be provided with bypass arrangements. Flow meters of positive displacement type shall be fitted with means preventing immediate loss of fuel supply in case of blockage if this will lead to loss of propulsion plant or auxiliary power.

4.10.6 The inlet connection of suction lines for service and settling tanks shall be arranged such as to avoid settled water and impurities from entering the fuel supply system.

4.10.7 Fuel oil booster units shall be protected against pressure peaks.

Guidance note:
The protection may be by means of dampers.

Dampers may be dispensed with if adequate damping is confirmed by the engine manufacturer or engine licensor.

---end---of---guidance---note---

5 Thermal oil systems

Thermal oil systems shall be arranged and installed in accordance with requirements given in DNVGL-鲁-SHIP Pt.4 Ch.6.

6 Feed water and condensation systems

6.1 Feed water pumps and piping

6.1.1 Feed water pumps installed to meet the requirements for redundancy shall be independently driven.

6.1.2 If feed water pre-heaters are fitted in feed water lines by-pass arrangements shall be provided enabling repair of a heater without interrupting the feed water supply.

6.1.3 Feed water piping shall be fitted with valves at the boiler inlet, as stated in DNVGL-鲁-SHIP Pt.4 Ch.7 Sec.5.

6.2 Feed water heating

6.2.1 For steam boilers with design pressure above 7 bar arrangements for pre-heating and de-aeration of the feedwater before entering the boiler shall be provided.

6.2.2 The pre-heating arrangement shall be capable of maintaining the temperature above 80°C when boilers are operated at maximum load during normal service.
6.3 Feed water tanks

6.3.1 Reserve feed water tanks shall be provided, with a capacity corresponding to at least twice the hourly evaporation rate of the main boilers.

6.3.2 Feed water tanks shall be separated from oil tanks by cofferdams.

6.3.3 Piping for feed water tanks shall be so arranged so that the water cannot be contaminated by oil or oily water.

6.4 Condensate from steam heating of tanks

6.4.1 Where fuel or lubricating oil tanks, heaters or purifiers are heated by steam in pipe coils, the condensate shall be led into an observation tank. This tank shall be placed in an easily accessible, well ventilated and well illuminated position where it can easily be observed whether the condensate is free from oil or not.

6.5 Evaporators

Evaporators for main boilers, see DNVGL-RU-SHIP Pt.4 Ch.6 Sec.5

7 Steam systems

7.1 Steam piping

7.1.1 Water pockets in the steam flow lines shall be avoided as far as practicable in order to prevent water hammer in the system. If this cannot be avoided, drain cocks or valves shall be fitted in such places so that the pipes may be efficiently drained while in operation.

7.1.2 Non-insulated steam pipes shall not be led through spaces or tanks without satisfactory possibilities for removal of the heat.

7.2 Shut-off valves

7.2.1 If two or more boilers are connected to a common header or steam manifold the steam connection to each boiler shall be provided with two shut-off valves with a free blowing drain in between. This requirement does not apply to exhaust gas economisers with forced circulation.

7.2.2 Where blow-downs from two or more boilers are connected to a common discharge, two valves shall be fitted to each discharge.

7.2.3 Heating coils of tanks containing fuel or oil residues, e.g. service tanks, sludge tanks, leak oil tanks and bilge water tanks, shall be provided with shut-off valves at the inlet and outlet of the tank. In addition a testing device shall be fitted at the outlet of the tank.

7.3 Safety valves

The discharge from safety valves shall be to a point where hazard is not created, see DNVGL-RU-SHIP Pt.4 Ch.7 Sec.5.
7.4 Blow down valves on unit's side

The blowdown valve on the unit's side shall be fitted in a readily accessible position. It shall be located above the level of the floor plating in such a way that it is easy to verify whether it is open or shut. The cock handle shall not be removable unless the cock is shut, and if a valve is fitted, the wheel shall be fixed to the spindle (See also Sec.1 [1.8.5] and DNVGL-RU-SHIP Pt.4 Ch.7 Sec.5).

8 Hydraulic systems

8.1 General

8.1.1 The redundancy requirement in [1.2] applies to pumps, filters and pressure reduction units.

8.1.2 Hydraulic systems shall be separated from other piping systems except lubricating oil systems as specified in [3.1].

8.1.3 The hydraulic fluid shall not corrode or attack chemically the components in the system. It shall have a flash point not lower than 150°C and shall be suitable for operation at all temperatures to which the system may normally be subjected.

8.1.4 Means for filtration and cooling of the fluid and for deflation of entrapped gases shall be incorporated in the system where identified as necessary.

8.1.5 Excessive pressure surges and pulses generated by pumps and valve operations shall be avoided. When necessary, pulsation dampers shall be fitted and shall preferably be connected directly to the source of vibrations. Design of the system shall normally be such that laminar flow is obtained.

8.1.6 Detachable pipe connections and valves in hydraulic pressure piping shall be at a safe distance from electrical appliances, boilers, exhaust pipes and other sources of ignition.

8.1.7 Air pipes from hydraulic oil circulation tanks and expansion tanks shall be lead to safe locations so that any escaping oil does not reach possible sources of ignition.

8.1.8 Oil circulation tanks or expansion tanks in engine rooms shall be provided with arrangements preventing overflow of oil (e.g. from generation of vapour due to moisture in the hydraulic oil). The following alternative arrangements are acceptable:

a) The free volume of the circulation tanks is sufficient for accumulating all the hydraulic oil in the system. A high level alarm is fitted in the tank at a level leaving sufficient free volume for containing the oil in the system.

b) The circulation tank or expansion tank is provided with an overflow pipe leading to a collecting tank. The cross sectional area of the overflow pipe is twice that of the return oil pipe.

c) The air pipe from the tank is lead to a safe position outside machinery space. The cross sectional area of the air pipe is twice that of the return oil pipe.

8.2 Hydraulic power supply

8.2.1 Requirements for hydraulic power supply to steering gears are given in DNVGL-RU-SHIP Pt.4 Ch.10 Sec.1.
8.2.2 Anchor windlasses may be fitted with one power unit provided the anchor(s) can be lowered independent of the hydraulic system.

8.2.3 Windlasses arranged for remote control shall have additional arrangement for local manual control.

8.3 Hydraulic cylinders
Certification of hydraulic cylinders is covered by DNVGL-CG-0194.

8.4 Accumulators

8.4.1 Hydraulic accumulators of the gas or hydraulic fluid type having

\[ pV > 1.5 \]

where

\[ p = \text{design pressure in bar} \]
\[ V = \text{volume in m}^3 \]

shall comply with DNVGL-RU-SHIP Pt.4 Ch.7, while requirements for smaller accumulators are as for piping.

8.4.2 For hydraulic accumulators of the gas or hydraulic fluid type the two media shall be suitably separated if their mixture can be dangerous or result in the contamination of the hydraulic fluid and/or loss of gas through absorption.

8.4.3 Each accumulator shall be protected on both gas and hydraulic fluid side by a safety device such as relief valve, fuse plug or rupture disc to prevent excess pressure if overheated. When the accumulator is an integral part of a system with such a safety device, the accumulator itself need not be supplied with a safety device.

8.4.4 The gas bottles for charging accumulators shall be in accordance with DNVGL-RU-SHIP Pt.4 Ch.7. Such bottles shall be clearly marked to prevent mixing up with other types of gas bottles on board.

8.4.5 Cast accumulators shall have an internal coating.

8.5 Hydraulic equipment

8.5.1 System components and arrangement shall satisfy the requirements in [8.1] to [8.4].

8.5.2 Piping and tubing to actuators and between actuators and local accumulators shall be hydrostatically tested to 1.5 times the system design pressure for 15 minutes.

**Guidance note:**
This requirement may be waived on a case-by-case basis. Aspects to be considered are maximum operating pressure compared to design pressure. Experience with workmanship may also influence the decision.

---End of Guidance Note---
8.5.3 Local accumulators used as back up power supply for essential systems shall be designed and located or protected to minimise the possibility of inadvertent isolation or mechanical damage which could prevent correct operation on demand.

8.5.4 Piping, tubing and components in systems required to operate in a fire scenario shall have adequate fire resistance properties to ensure correct system operation. This is particularly important for systems where hydraulic energy is required to activate or maintain control over the system. Fire test certificates for such system components may be requested.

8.5.5 Piping and tubing shall be flushed and cleaned before being connected to control systems.

8.5.6 Hydraulic oil return lines shall be designed with capacity to allow the maximum return flow during extreme conditions without reducing overall system performance. Care shall be taken to avoid the possibility of blockages at filters, vents or by mechanical damage or inadvertent operation of valves.

9 Pneumatic power supply

9.1 General

9.1.1 The redundancy requirement in [1.2] applies for compressors, filters, pressure reduction units when supplying power for control of main functions, and air treatment units (lubricator or oil mist injector and dehumidifier.

9.1.2 Air intakes for the compressors shall be so located as to minimise the intake of oil or water contaminated air.

9.1.3 Pipes between the compressors and pressure vessels shall not have connections to other machinery.

9.1.4 Valves on the air receivers shall be designed such that detrimental pressure shock does not arise in the pipes when the valves are opened.

9.1.5 Pipes from air compressors with automatic start shall be fitted with a separator or similar device to prevent condensation from draining into the compressors.

9.1.6 If the unit or installation has a pneumatic auxiliary steering gear, two starting air compressors with a total capacity sufficient for normal operation of the auxiliary steering gear shall be provided.

9.1.7 Pressure lines connected to air compressors shall be fitted with non-return valves at the compressor outlet.

9.1.8 Air driven whistles shall be supplied from at least two compressed air receivers.

9.2 Pneumatic equipment

9.2.1 Components requiring extremely clean air shall not be used. Extremely small openings in air passages shall be avoided.
9.2.2 Main pipes shall be inclined relative to the horizontal as far as possible, and drainage shall be arranged.

9.2.3 Pipes and other equipment made of plastic materials are accepted if they have satisfactory mechanical strength, low thermoplasticity, high oil resistance, and are flame retardant. For application see Sec.2 [2.5].

9.2.4 Air to instrumentation equipment shall be free from oil, moisture and other contamination. Condensation shall not occur at relevant pressures and temperatures. For air flowing in pipes which are located entirely inside the machinery space and accommodation, the dew point shall be more than 10°C below the ambient temperature, but need normally not be lower than 5°C. The dew point of air flowing in pipes on open deck shall be below -25°C.

9.2.5 Local accumulators used as back up air supply for essential systems shall be designed and located or protected to minimise the possibility of inadvertent isolation or mechanical damage which could prevent correct operation on demand.

9.2.6 Piping and tubing shall be cleaned and dried before connected to control systems.

10 Pneumatic starting arrangements

10.1 General
For diesel engine starting systems, see also the DNVGL-RU-SHIP Pt.4 Ch.3. For starting up from «dead ship», see Sec.1 [2.3.13]. Electrical starting systems are described in DNVGL-OS-D201 Ch.2 Sec.2.

10.2 Capacity

10.2.1 Starting systems for internal combustion engines and gas turbines shall have capacity for a number of starts specified in Table 1 without reloading of air receivers.

Table 1 Capacity for number of starts

<table>
<thead>
<tr>
<th>Duty of engines</th>
<th>Number of starts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engines for driving electric generators, emergency</td>
<td>3 starts each</td>
</tr>
<tr>
<td>generators and engines for other purposes</td>
<td></td>
</tr>
</tbody>
</table>

10.2.2 If a starting system serves two or more of the above specified purposes, the capacity of the system shall be the sum of the capacity requirements.

10.2.3 For multi-engine propulsion plants the capacity of the starting air receivers shall be sufficient for 3 starts per engine. However, the total capacity shall not be less than 12 starts and need not exceed 18 starts.

Guidance note:
The above applies for generators generating power for thrusters on column-stabilised units or ships.

---end---of---guidance---note---
10.2.4 Requirements to starting of emergency generators are given in DNVGL-OS-D201 Ch.2 Sec.2 [3.3]. Drivers for fire pumps required to be fed from emergency generator shall follow the same starting requirements as for emergency generators.

10.2.5 Compressors shall be installed with total capacity sufficient for charging air receivers of capacities specified in [10.2.1] to [10.2.4] from atmospheric to full pressure in the course of one (1) hour.

10.3 Redundancy

10.3.1 Two or more compressors of total capacity as specified in [10.2.5] shall be installed. The capacity shall be approximately equally shared between the compressors. At least one of the compressors shall be independently (not direct connected to the engine) driven.

10.3.2 Engines started by compressed air shall have at least two independent starting air receivers of about equal capacity.

10.4 Emergency generators

10.4.1 If the emergency generator is arranged for pneumatic starting, the air supply shall be from a separate air receiver.

10.4.2 The air receiver shall not be connected to other pneumatic systems, except for the starting system in the engine room. If such a connection is arranged, the pipeline shall be provided with a screw-down non-return valve.

11 Heating, ventilation and air conditioning (HVAC)

11.1 General

11.1.1 The ventilation system shall be designed to maintain acceptable working and living environment for the personnel and non-detrimental conditions for equipment and machinery.

Guidance note:
For requirements related to ventilation of hazardous and non-hazardous areas, see DNVGL-OS-A101 Ch.2 Sec.3.

11.1.2 Regarding ventilation of spaces in which machinery is operated and where flammable or toxic gases or vapours may accumulate, where low oxygen atmosphere may occur, machinery spaces and emergency generator room, see also Sec.1 [1.1.4] and Sec.1 [1.1.5].

11.2 Accommodation and control stations

The HVAC system with air intakes shall be so located and constructed that fire hazardous, noxious gases, exhaust, dust, etc. are prevented from entering into the living quarters.

11.3 Ventilation of machinery spaces

11.3.1 The capacity of the ventilation plant shall be such as to provide comfortable working condition in the engine room, to supply the necessary combustion air to the diesel engines, boilers, and to prevent heat-sensitive apparatus from overheating.
11.3.2 In order to meet these requirements, the air shall be distributed to all parts of the engine room, so that pockets of stagnant hot air are avoided. Special considerations should be given to areas with large heat emission and to all normal working areas, where reasonably fresh and clean outdoor air should be provided through adjustable inlet devices.

**Guidance note:**
For units with unrestricted location, the temperature rise from air intake to air passing from the engine room up to the casing should be maximum 10°C for an outside air temperature of maximum +35°C.

---end---of---guidance---note---

11.3.3 Approximately 50% of the ventilation air should be delivered at the level of the top of the diesel engines, close to the turbo-charger inlets, care being taken to ensure that no sea water can be drawn into the air inlets.

11.3.4 The required air flow for combustion and evacuation of heat emission shall be calculated according to ISO 8861 or another recognised maritime standard.

11.3.5 Both the supply and exhaust fans shall be arranged with redundancy according to [1.2].

11.3.6 The air exhaust fans shall be designed to maintain a slight positive pressure in the engine room.

**Guidance note:**
The positive pressure should normally not exceed 50 Pa.

---end---of---guidance---note---

11.3.7 The purifier room, where installed, shall have a separate exhaust fan discharging to open air remote from any air inlet.

11.4 Ventilation of gas hazardous areas

11.4.1 For requirements to ventilation in relation to hazardous areas, see DNVGL-OS-A101 Ch.2 Sec.3 [3].

11.4.2 Air inlet ducts designed for constant relative under-pressure shall be rigidly constructed to avoid air leaks.
(See IACS UR D.8.3.2)

11.5 Fans serving hazardous spaces

11.5.1 Electric fan motors shall not be installed in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served.

11.5.2 Fans shall be designed with the least possible risk for spark generation.
(See IACS UR D.8.3.2)
Guidance note:
Recommended radial air gap between the impeller and the casing should not be less than 0.1 times the diameter of the impeller shaft in way of the bearing, but not less than 2 mm. It need not be more than 13 mm.

---e-n-d---o-f---g-u-i-d-a-n-c-e-n-o-t-e---

11.5.3 The parts of the rotating body and of the casing shall be made of materials which are recognised as being spark proof, and they are to have anti-static properties. Furthermore, the installation of the ventilation units shall be such as to ensure the safe bonding to the hull of the units themselves. The following combinations of materials and clearances used in way of the impeller and duct are considered to be non-sparking:

a) Impellers and/or housing of non-metallic material, due regard being paid to the elimination of static electricity.

b) Impellers and housings of non-ferrous metals.

c) Impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing.

d) Impellers and housing of austenitic stainless steel.

e) Any combination of ferrous (including austenitic stainless steel) impellers and housing with not less than 13 mm tip design clearance.

11.5.4 Any combination of an aluminium or magnesium alloy fixed or rotating component, and a ferrous fixed or rotating component, regardless of tip clearance, is considered a spark hazard and shall not be used in these places.

11.6 Ductwork

11.6.1 The ductwork shall be constructed according to recognised maritime standard or ISO 1461, SMACNA, EN 12238, ISO 12239, ENV 12097, etc.

11.6.2 The ventilation ducts shall be of non-combustible materials as specified in DNVGL-OS-D301 Ch.2 Sec.1.

12 Use of gas and crude oil for auxiliary boilers and turbines

12.1 General
This section covers use of gas and crude oil in an enclosed space. Gas fuelled turbines and/or boilers located on topsides deck should follow the principles given in DNVGL-OS-E201.

12.2 Arrangement of engine room

12.2.1 Ventilation of engine and boiler room shall be carried out at a pressure which is above atmospheric pressure. The ventilation system shall be independent of all other ventilation. The number of the pressure fans for common engine or boiler room shall be such that the capacity is not reduced by more than 50%, if one fan is out of operation.

The ventilation system shall ensure a good air circulation in all spaces, and in particular to prevent the formation of gas pockets in the room.
12.2.2 Gas turbines and gas handling machinery (e.g. compressors) should be located in an enclosure with minimum A-0 fire rating.

12.2.3 Inside the enclosure, adequate ventilation shall always be provided. From initiation of the start sequence of the turbine, until the turbine casing and exhaust duct are at a temperature below the lowest of:
— 80% of the fuel auto-ignition temperature
— or 200°C.

12.2.4 Within the enclosure a continuous dilution ventilation shall be provided. The ventilation rate shall be adequate to maintain a fuel and air mixture below 20% lower explosion limit LEL (90 air changes per hour is normally considered adequate). Reliability of ventilation air supply (redundancy of fans and power supply) shall comply with requirements in DNVGL-OS-A101 Ch.2 Sec.3 [3.5].

12.2.5 A quick acting block valve shall be fitted on all fuel supply lines. The valve shall be located outside the main enclosure for the turbine or boiler, i.e. outside the engine room if installed inside the hull. (The valve can be incorporated in the block and bleed arrangement described in [12.3]).

12.2.6 As far as practicable, turbines and fuel lines shall be located or shielded so that fragments from damaged rotating elements (e.g. discs) will not cause ruptures or critical damage to essential equipment or facilities.

12.3 Supply lines for gas and crude oil

12.3.1 Gas and crude oil supply lines shall not pass through the accommodation or control station spaces. Supply lines may pass through or extend into other spaces if the lines are enclosed in a double pipe or duct, see Figure 1 and Figure 2.

12.3.2 Gas supply lines passing through enclosed spaces shall be completely enclosed by a double pipe or duct. This double pipe or duct is to fulfil one of the following:

a) The gas piping shall be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes shall be pressurised with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms shall be provided to indicate a loss of inert gas pressure between the pipes.

b) The gas fuel piping shall be installed within a ventilated pipe or duct. The air space between the gas fuel piping and the wall of the outer pipe or duct shall be equipped with mechanical under pressure ventilation having a capacity of at least 30 air changes per hour. This ventilation capacity can be reduced to 10 air changes per hour provided automatic filling of the duct with nitrogen upon detection of gas is arranged for. The fan motors shall be placed outside the ventilated pipe or duct. The ventilation outlet shall be covered by a protection screen and placed in a position where no flammable gas-air mixture may be ignited.

12.3.3 For high-pressure piping the design pressure of the ducting shall be taken as the higher of the following:
— the maximum built up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space
— local instantaneous peak pressure in way of the rupture (p*): this pressure shall be taken as the critical pressure and is given by the following expression:
\[ p^* = p_0 \cdot \left( \frac{2}{k+1} \right)^{\frac{k}{k-1}} \]

- **\( p_0 \)**: maximum working pressure of the inner pipe
- **\( k \)**: \( C_p / C_v \), constant pressure specific heat divided by the specific volume specific heat
- **\( k \)**: 1.31 for CH₄

The tangential membrane stress of a straight pipe shall not exceed the tensile strength divided by 1.5 (\( R_m / 1.5 \)) when subjected to the above pressure. The pressure ratings of all other piping components are to reflect the same level of strength as straight pipes.

**Guidance note:**
As an alternative to using the peak pressure from the above formula, the peak pressure found from representative tests can be used.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

**12.3.4** For low pressure piping the duct shall be dimensioned for a design pressure not less than that of the gas pipes. The duct shall be pressure tested to demonstrate that it can withstand the expected maximum pressure at gas pipe rupture.

**12.3.5** The ventilated pipe or duct shall terminate at a ventilated hood or casing arranged to cover the areas occupied by flanges, valves etc. and the piping at the gas or crude oil control unit. The hood or casing shall be installed or mounted to permit ventilation air to sweep across the control unit and be exhausted at the top of the hood or casing. The duct and hood shall be fitted with gas-tight inspection openings in way of connections of pipes.

*Figure 1 Example of gas supply to gas turbine*
12.3.6 There shall be an interlock between gas supply and ventilation, such that the ventilation between outer and inner walls will always be in operation when there is gas in the supply line. In or immediately inside the duct outlet, continuous gas detection shall be provided.

12.3.7 A separate and independent supply line shall be arranged for each combustion engine and gas turbine.

12.3.8 The minimum nominal wall thickness of the pipes for gas and crude oil in non-hazardous areas shall be designed for a pressure of at least 50% higher than normal working pressure but not to be less than ANSI. pipe schedule 40.

12.3.9 Full penetration butt welded joints shall be used for enclosed crude oil and gas pipes in non-hazardous areas. Detachable pipe connections shall be limited to those which are necessary for the installation purpose only.

12.3.10 Exposed (i.e. not enclosed in a gas tight pipe or duct) crude oil and gas pipes may be accepted in non-hazardous areas after special consideration in each case, provided compliance with the following minimum criteria:

a) 100% non-destructive testing of welded connections shall be carried out.

b) Strength of pipes (wall thickness with respect to diameter) and the arrangement (support etc.) are such that the piping is able to withstand the maximum possible combined load from internal and external forces it may be exposed to.

c) Clearly identifiable colour code shall be used for the pipes.

d) Alarm for detected gas in machinery room with maximum concentration of 20% of (LEL).

e) No flanges are fitted in the non-hazardous area.

12.3.11 The following fault conditions shall release alarm and automatic shut-down of gas and crude oil supply:

a) Detected gas of maximum 20% of the LEL in the ventilated duct. For crude oil fired units, detection of liquid at all low points in the ventilated duct may be accepted as an alternative.

b) Detected gas of maximum 20% of the LEL in engine and boiler room. This requirement may be dispensed with if the ducting has no opening (e.g. hood) into the machinery space.
c) Loss of ventilation in the duct.
d) Abnormal pressure variation in the fuel supply line.
e) Detected fire in the engine and boiler room.

12.4 Arrangement of gas supply for boilers and turbines

12.4.1 The gas may be taken directly from the oil production facilities. The complete system for treatment of gas including pressure vessels, compressors, separators, filters, pressure control valves etc., shall be located in hazardous area and separated from the engine and boiler room by gas-tight bulkheads.

12.4.2 A double block and bleed arrangement shall be fitted on the gas supply line, see Figure 1 and Figure 2. The system shall shut off the gas supply and vent the gas piping inside the engine room and enclosures to a safe location (see area classification code for classification of discharge point).

Guidance note:
Single block and bleed isolation may be accepted for short supply lines, if this is in compliance with the owners isolation strategy.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

12.4.3 The «block and bleed» valves shall be arranged for both automatic and manual operation, and shall be interlocked. Venting of the gas supply lines shall take place when gas is detected in the duct and when the unit is shut down. The manual operation shall be carried out from the boiler or turbine control panel and from a location outside the engine room.

12.4.4 Measures for gas-freeing of the complete piping system shall be provided. Warning and notice plate shall be provided, which clearly indicates that gas-freeing is not to take place through a recently extinguished combustion chamber.

12.4.5 The switch-over from gas operation to oil operation, or vice versa, shall be possible during normal running condition.

12.5 Arrangement of crude oil supply for boilers

12.5.1 Crude oil may be taken directly from the crude oil storage tanks or from other suitable tanks. These tanks shall be separated from non-hazardous areas by means of cofferdams with gas-tight bulkheads.

12.5.2 The complete system for treatment of crude oil or slop, i.e. pumps, strainers, separators and heaters, if any, shall be fitted in hazardous area, and separated from engine and boiler room by gas-tight bulkheads. When crude oil is heated by steam or hot water, the outlet of the heating coils shall normally be led to a separate observation tank located together with above mentioned components. This closed tank shall be fitted with a venting pipe led to the atmosphere in a safe position and with the outlet fitted with a suitable flame proof wire gauze of corrosion resistant material which shall be easily removable for cleaning.

12.5.3 Electrical motors for pumps, separators, etc., shall be fitted in non-hazardous area. Where drive shafts pass through pump room bulkhead or deck plating, gas-tight glands shall be fitted. The glands shall be efficiently lubricated from outside the pump room.

12.5.4 The crude oil piping shall, as far as practicable, be fitted with a slope rising towards the boiler so that the oil naturally returns towards the pump room in the case of leakage or failure in delivery pressure.
12.5.5 In way of the bulkhead to which the duct is connected, delivery and return oil pipes shall be fitted on the pump room side, with shut-off valves remotely controlled from a position near the boiler fronts or from the machinery control room.

12.5.6 When using fuel oil for delivery to and return from boiler fuel oil burning units, the fuel oil delivery to and return from burners shall be effected by means of a suitable mechanical interlocking, so that running on fuel oil automatically excludes running on crude oil or vice versa.

12.5.7 A quick closing master valve shall be fitted on the oil supply to each boiler manifold.

12.6 Construction of boilers and burners

12.6.1 The boilers shall be so constructed that there is no danger that gas pockets are formed in any place in the firing and flue gas part of the boiler.

12.6.2 Each boiler shall have a separate flue gas line led up to the top of the funnel.

12.6.3 The burners for crude oil and gas shall be of such construction that they effectively maintain complete and stable combustion during all operating conditions.

12.6.4 The monitoring device for detecting flame failure shall be of the design «fail to shut-down of fuel supply».

12.6.5 Boilers for crude oil shall be fitted with a tray or gutterway of suitable height, and be placed in such a way as to collect any possible oil leakage from burners, valves and connections. The tray or gutterway shall be fitted with a draining pipe discharging into a separate tank. This tank shall be fitted with a venting pipe led to the open in a safe position and with the outlet fitted with wire gauze made of corrosion resistant material easily dismountable for cleaning. The draining shall be fitted with an arrangement to prevent the return of gas to the boiler or engine room.

12.6.6 Crude oil pumps shall be arranged for remote stop from the machinery control room and from near the boiler front.

12.7 Gas operated combustion engines

12.7.1 Construction and installation of gas operated engines shall be specially considered in each case. Technical requirements to such installations shall be based on applicable parts of DNVGL-RU-SHIP Pt.5 Ch.7 Sec.16 and DNVGL-RU-SHIP Pt.6 Ch.2 Sec.5.

12.7.2 The requirements for gas supply shall in general be as required in [12.2] and [12.3].

13 Pollution prevention

13.1 Application

13.1.1 Arrangement and equipment for handling and disposal of oily water and oil residues shall be as per requirements in DNVGL-RU-SHIP Pt.4 Ch.6 Sec.8 [1].
13.1.2 Arrangement and equipment for exhaust gas cleaning systems for the purpose of reducing NOx emissions shall meet requirements in DNVGL-RU-SHIP Pt.4 Ch.6 Sec.8 [2].

13.1.3 Arrangement and equipment for exhaust gas cleaning systems for the purpose of reducing SOx emissions shall be meet requirements in DNVGL-RU-SHIP Pt.4 Ch.6 Sec.8 [3].
SECTION 5 MACHINERY AND MECHANICAL EQUIPMENT

1 General

1.1 Principles

1.1.1 Requirements in this section are applicable to machinery and equipment primarily related to the following:

— power generation
— propulsion
— steering
— drainage and bilge pumping
— ballasting
— stored product handling
— anchoring and mooring
— jacking systems
— gravity tanks and pressure vessels and associated piping systems for:
  — toxic fluids
  — fluids with flash point below 100°C
  — fluids with temperature above 220°C
  — fluids with pressure above 40 bar
  — thermal-oil heaters
  — boilers and steam piping systems
  — oil burners and oil firing equipment
  — compressed gases where $P \times V \geq 1.5$
  
  $P = \text{design pressure in bar}$
  $V = \text{pressure vessel volume in m}^3$.  

1.1.2 Machinery and equipment shall be designed, fabricated and tested in accordance with the requirements given in this section and recognised codes and standards.

2 General marine equipment

2.1 General

For machinery and equipment with similar application as for ships, the technical and procedural requirements as given in the DNVGL-RU-SHIP shall be used. Internationally recognised codes and standards may be accepted.

2.2 Propulsion and auxiliary machinery

2.2.1 For combustion engines in hazardous areas, see DNVGL-OS-A101 Ch.2 Sec.2 [3.3].

2.2.2 Pressurisation of a space will be accepted to make it non-hazardous, provided the following minimum requirements are complied with:

— pressurisation air is taken from a safe area
— an alarm system is fitted to indicate loss of air pressure
— an air-lock system with self-closing doors is fitted
2.2.3 Efficient spark preventing equipment shall be fitted to the exhaust from all combustion engines and equipment, except gas turbines. Means to give warning of failure of water supply to water-cooled spark preventing equipment shall be provided.

2.2.4 Exhaust gases shall be discharged so as not to cause any inconvenience to personnel or a dangerous situation during helicopter operations.

2.2.5 The temperature of piping and machinery which may be exposed to gas and crude oil shall not exceed 200°C.

2.3 Anchoring and mooring equipment
For requirements for anchoring and mooring equipment and towing devices, see DNVGL-OS-E101.

2.4 Steering machinery

2.4.1 Steering machinery for ship-shaped units shall comply with the technical requirements of DNVGL-RU-SHIP Pt.4 Ch.10.

2.4.2 Steering machinery for column-stabilised units based on a rudder arrangement shall be subject to special consideration based on applicable parts of the requirements given in [2.4.1].

3 Jacking systems

3.1 Introduction

3.1.1 Application
The requirements in this sub section apply to jacking systems for self-elevating offshore units.

Guidance note:
The jack house frame, fixation system and the welding connection between rack and leg structure are described in DNVGL-OS-C104 and DNVGL-OS-C201.

3.1.2 Structure
This sub section is structured as follows:
— [3.2] defines technical requirements as applicable for all different types of jacking system
— [3.3] defines technical requirements for rack-pinion jacking systems
— [3.4] defines technical requirements for ram-pin systems
— [3.5] defines technical requirements for rubber block friction systems.
Jacking system commissioning test and inspection requirements are given in Ch.3 Sec,3

3.1.3 Documentation requirements
For documentation requirements for classification see Ch.3 Sec.1.
3.1.4 Failure mode and effect analysis
A failure mode and effect analysis (FMEA) according to DNVGL-OS-D202 Ch.3 Sec.1 shall be carried out.

3.1.5 Load spectrums and conditions
A relevant load-time spectrum shall be specified. This shall include at least the following:
- raising of the legs
- lowering of the legs
- raising of the platform
- lowering of the platform
- exceptional use (e.g. one or more units out of service)
- pre-load holding (static)
- pre-load raising (if permitted)
- pre-load lowering
- storm holding (static)
- motor stalling torque (for pinion rack systems)
- leg rotation loads

3.1.6 The elements in the load-time spectrum listed in [3.1.5] (except motor stalling torque) are vertical net loads on the leg. The following shall be included in the load spectrum:
- friction losses from leg guiding in the hull structure
- effect of variation in location of the centre of gravity of the unit or installation.

3.1.7 Unless otherwise documented, the guide friction may be taken as 10% of the net vertical force in normal operation. When lifting in a tilted position (due to soil penetration in pre-load) higher guide friction shall be assumed. When evaluating the stresses in the jacking machinery, the influence of friction in bearings and on gear flanks shall be considered.

3.2 General requirements

3.2.1 Load conditions
All jacking machinery components shall be designed for any relevant load condition mentioned in [3.1.5]. Design safety factors etc. are valid for all foreseen operating conditions.

Guidance note:
For loads that are not foreseen, but may occur, such as motor stalling torque, lower safety factors may apply.

3.2.2 When a design is documented by means of tests in lieu of calculations, or by combinations thereof, lower safety factors than those required by calculations may be accepted. The level will be considered on the basis of the extent of the testing and the acceptance criteria for the various parts after the test. When units or parts of units are tested, normally the whole load spectrum shall be applied and each load level shall be multiplied with the required safety factor. When different safety factors apply, such as for tooth root strength and flank durability, the highest (i.e. tooth root strength) shall be used for testing purposes. (Due to the elevated loads, some flank deterioration is considered acceptable in this case).

3.2.3 Jacking mechanisms shall be arranged so that a single failure of any component does not cause an uncontrolled descent of the unit.
(See MODU Code 4.14.1)
3.2.4 Material
General requirement to material selection are given by DNVGL-OS-C101 Ch.2 Sec.3 [4].
For rack plates with specified minimum yield stress equal to 690 N/mm² in rack and pinion jacking systems steel grade VL E690 is acceptable for rack plates with thickness up to 250 mm and for design temperature down to -20°C.

3.2.5 Materials in forged and cast components shall satisfy the requirements given in DNVGL-OS-B101 Ch.2 Sec.4 and DNVGL-OS-B101 Ch.2 Sec.5. For materials with yield strength value higher than given in the table, the elongation shall be not less than 12%. Materials in fixation chocks in the fixation system (if installed) shall be equivalent to the material in the racks.

3.2.6 Arrangement
The jacking units shall be arranged so that they can be removed individually for servicing.

3.2.7 The jacking system shall be arranged in such a way that visual monitoring during jacking is possible, this includes the fixation system.

3.2.8 The jacking systems shall be designed such that the rig can be jacked to a safe position in case of single failure within 3 hours.

Guidance note:
This can be achieved with the use of for example replacements, operational procedures, repairs etc.

3.2.9 The jacking units shall be supported in such a way that elastic jack-house frame deflections are not harmful to the jacking operation such as pinion-rack mesh.

3.2.10 Ball and roller bearings shall have a minimum \( L_{10a} \) (ISO 281) life time that is suitable with regard to the specified overhaul intervals. The influence of the lubrication oil film may be taken into account for \( L_{10a} \), provided that the necessary conditions, in particular cleanliness, are fulfilled.

3.2.11 The surface pressure (on projected area) in plain bearings shall not exceed 50% of the yield strength of the bearing material when the maximum load is applied. The bearings and lubrication are also to be designed to avoid wear that could be harmful for the gear meshes.

3.2.12 Chock pad properties shall be documented. Extent of additional documentation shall be determined by FMEA and novelty of design. Possibilities for replacement of these flexible mountings shall be taken into account.

3.2.13 Flexible (sandwich) rubber pads shall be protected by an oil based coating.

3.2.14 Electrical installations
Principles, technical requirements and guidance for design, manufacturing and installation of electrical installations, shall be in accordance with DNVGL-OS-D201, and be classified as an important system.

3.2.15 Power supply shall be arranged so that no single failure prevents the jacking operation.
3.2.16 Control and monitoring
The control and monitoring system shall be in accordance with R3 requirements described in DNVGL-OS-D202, and be classified as an important system. General requirements in DNVGL-OS-D202 applies.

3.2.17 In case of failure in the control system, jacking operations shall be stopped automatically for evaluation.

3.2.18 Emergency stop of jacking operation shall be possible from the vicinity of the central jacking control station. Emergency stop circuit shall be independent of the control system and failure in the circuit shall be alarmed.

3.2.19 The jacking system shall be operable from a central jacking control station.
(See MODU code 4.14.2)

3.2.20 A communication system shall be provided between the central jacking control and a location at each leg.
(See MODU code 4.14.4)

3.2.21 The jacking system shall include the following control and monitoring arrangements, when applicable:
— Remote indication and alarm if a brake is not released when power applied to the motors. The brake alarm shall be given by an independent mechanical or electrical sensor.
— Remote indication and alarm for overheating of an electric motor.
— A permanent remote indication of loads during jacking and retrieval shall be provided. For a lattice leg unit the load per chord is as a minimum to be presented. Alarm signal to be given when maximum load is exceeded.
— Audible and visible alarm to indicate out-of-level.
— Audible and visible alarm to indicate rack phase differential.
— Indication of inclination.
— Indication of power consumption.
— Indication of hydraulic/pneumatic pressure.
— Indication of position of pin and yoke.
— Indication of speed.
— Indication of frequency.
(See MODU code 4.14.3)

3.3 System specific – rack and pinion

3.3.1 General requirements
Jacking machinery (including pinion-rack) shall be designed so that an overload failure occurs in open machinery prior to enclosed machinery. This means that conditions such as e.g. a motor stalling or lifting with a locked brake shall cause clearly visible deformation in easily accessible parts such as pinion or (preferably) rack before any critical failure occurs in an enclosed gearbox.

3.3.2 The jacking machinery shall be designed to avoid self-locking when descending.

3.3.3 The jack-house frame and leg-rack shall have dimensional tolerances that permits an involute gear mesh (i.e. contact ratio is above unity) between pinion and rack under all operating conditions.
3.3.4 The motors shall be provided with a possibility for mechanical wind-up, e.g. a square free-shaft end for crank application. This requirement is not applicable for systems with means for equalizing loads and the possibility to remove individual gears.

3.3.5 For automatic fixation systems, an interlock shall be provided between electric motors and fixation rack system, in order to prevent power supply to the motors when the fixation rack is engaged.

3.3.6 If the system does not include a fixation system, the pinion, gearbox and motor shaft shall be considered as structural components. Design shall hence be in line with principles in standards referenced under [3.1.2].

3.3.7 Gearing
Details on calculation of gearing are given in DNVGL-CG-0036.

Guidance note:
This contains information on calculation of tooth root strength (fractures or deformation) and flank surface durability (pitting, spalling and case crushing) and scuffing for enclosed gear units.

3.3.8 The following minimum safety factors apply (taking into account the principles given in [3.2.4]):

Tooth root strength
— applicable to both enclosed and open gearing:
  — safety against accumulated fatigue due to all lifting and descending loads $S_F = 1.5$
  — safety against static loads as storm holding or pre-load holding $S_F = 1.35^{(1)}$
  — safety against one motor stalling $S_F = 1.2$.

Flank surface durability
— applicable to enclosed gearing, except for case crushing (surface hardened gearing) which also applies to open gears:
  — safety against accumulated fatigue due to all lifting and descending loads $S_H = 1.0$
  — safety against case crushing under static loads and one motor stalling $S_H = 1.0$.

Scuffing
— applicable to enclosed gearing:
  — safety $S_S = 1$ except for motor stalling.

(1) Design principles found in DNVGL-OS-C104 can also be utilised.

Welded gears shall be stress relieved. Welds that suffer a stress variation during the rotation shall be designed to prevent (low cycle) fatigue.

The permissible stress range in a full penetration weld with a smooth (accessible) backside is 0.5 times the yield strength of the softer material. For inaccessible backside or non-full penetration welds the permissible stress range is 0.2 times the yield strength of the softer material. The stress range shall be determined by finite element method analyses and is to consider any stress concentration.

3.3.9 Pinion and rack
For pinions utilising a non-involute dedendum, the tooth profile shall be specified on a drawing.

The safety factors given in [3.3.8] apply for the pinions and racks, with exception of rack tooth root strength for storm holding and motor stalling where tooth deformation is acceptable.
3.3.10 For calculation of tooth root stresses of pinion and rack, load application at the tooth tip shall be assumed. Further guidance can be found in DNVGL-CG-0036 Appendix C.

3.3.11 NDT requirements for pinions, unless otherwise agreed with the manufacturer, shall be according to DNVGL-RU-SHIP Pt.4 Ch.2 Sec.1.

The below acceptance criteria requirements shall apply to the pinions unless otherwise justified by evaluation of stress level combined with fracture mechanics:

— For forged components: IACS Recommendation no.68, inspection zone 1.
— For surface defects: linear indications in the toothed part are not permitted.

Guidance note:
To prevent excess wear on the pinions, it is recommended that they have a surface hardness 10% higher than the hardness of the rack.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.12 Gear casings and bearing structure
Welded gear casings and supporting structure around bearings shall be stress relieved.

3.3.13 The casings and bearing structures shall be designed to prevent deflections that may be harmful for the gearing.

3.3.14 The design shall enable inspections of the gearing and plain bearings. For parallel shaft gears this means inspection openings, and for epicyclic gears openings for access with boroscope.

3.3.15 Shafts and connections
Connections as shrink fitting, bolted wheels, flange bolts, splines, keys, etc. shall fulfil the criteria given in DNVGL-RU-SHIP Pt.4 Ch.4. Other international standards may be agreed case by case.

3.3.16 Shafts shall be designed to have safety against yielding that is consistent with the tooth root strength criteria in [3.3.7]. Combined bending and torsion shall be considered. Stress concentration factors may be taken from relevant literature or from DNVGL-CG-0038 with safety factors as described in [3.3.8].

3.3.17 Special consideration shall be given to high speed shafts accumulating more than $10^4$ cycles.

3.3.18 For shafts (including motor shaft) that are subjected to the forces from the brakes, the materials shall fulfil the requirements as described in [3.2].

3.3.19 Brakes
A shaft brake shall be provided. This is to engage automatically in the event of power failure to the jacking machinery.

Guidance note:
For systems with variable speed drives the brake lining might require run-in prior to installment in order to achieve the required braking capacity.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.20 The brake shall be designed to operate at least at a shaft speed corresponding to the maximum operational jacking speed + 10%.
3.3.21 The static brake friction torque shall not be less than 1.3 times the maximum torque at the brake position.

3.4 System specific - ram and pin system

3.4.1 Requirements for ram and pin jacking systems are based only on hydraulic principles. General design requirements for the hydraulic system are described in Ch.2 Sec.4 [8] Hydraulic systems.

3.4.2 For general requirement for structural design, see DNVGL-OS-C104 or DNVGL-OS-C201.

3.4.3 Normally the fixed crosshead and the movable crosshead shall be provided with at least two pins each. The movable crosshead shall be connected to the hull structure of the unit via at least two hydraulic rams.

3.4.4 The hydraulic system shall be fitted with safety or load holding valves on all main circuits protecting against unintended movements in case of hose rupture.

3.4.5 The system shall be arranged in such a way that simultaneous retraction of all pins is prevented.

3.5 System specific - rubber block friction system

3.5.1 Requirements for rubber block friction systems are based on pneumatic principles only. General design requirements for pneumatic systems are given in Ch.2 Sec.4 [9].

3.5.2 The holding capacity between rubber block and shell of the tubular leg shall be at least 1.3 times the stormholding/preload.

3.5.3 The rubber block friction system uses the friction between the tubular leg and a greater number of rings of rubber blocks, which are pressed to the shell of the leg by compressed air. The rubber block rings shall be divided in several groups which are to be separately supplied from the compressed air system providing the contact pressure and for which the actual air pressure has to be monitored. If one group fails the groups remaining operable shall be capable of a holding capacity of 1.0 of the design load. Normally the fixed gripper and the movable gripper shall be provided with a group of rubber block rings. The movable gripper shall be connected to the hull structure of the unit via at least two hydraulic or pneumatic rams.

3.5.4 The control system shall permanently monitor the air pressure of the different rubber ring groups and automatically hold the pre-set air pressure. If there is the tendency that the air pressure of a group can only be kept by permanent operation of the compressors, a visible and audible alarm shall be activated. It shall be avoided, that all groups of rubber block rings get into a situation without compressed air at the same time.

3.5.5 The assumed friction coefficient between the rubber blocks and the shell of the tubular leg shall be agreed with DNV GL. To maintain this coefficient during practical operation, the shell of the tube shall be kept clean and free of oil or grease, etc. A cleaning device at the upper and lower end of a rubber block system is recommended. Before every lifting or lowering operation a check of the leg surface shall be done by the operating personnel.

3.5.6 The pneumatic system shall be designed so that a single failure, e.g. burst of a pneumatic tube or rupture of supply pipes, etc. does not lead to a complete failure of the system.
3.6 Alternative designs

Alternative designs will be considered on a case by case basis.
SECTION 6 PIPE FABRICATION, WORKMANSHIP, AND TESTING

1 General

1.1 Objectives
The section addresses joining quality and testing requirements intended to avoid piping failure due to poor manufacture and installation.

1.2 Application
The requirements of this section shall be applied to all piping and piping items designed under this standard.

2 Welding

2.1 General

2.1.1 The welding of pipes shall be carried out by qualified welders, using recognised welding procedures and welding consumables according to ASME IX or ISO 15609-1 as applicable.

2.1.2 Oxy-acetylene welding shall not be used for steel pipes in class I and II with outer diameter greater than 101.6 mm and/or wall thickness exceeding 10 mm.

2.1.3 Welding of pipes of copper and copper-nickel may be carried out by:
— gas tungsten arc welding (GTAW)
— gas metal arc welding (GMAW), for greater wall thicknesses
— other approved welding processes, subject to special consideration.

2.1.4 Welding of pipes of aluminium-brass shall be subject to special consideration.

2.1.5 Internal and external surfaces which shall be thermally cut or welded shall be clean and free from paint, oil, rust, scale, and other material that would be detrimental to either the weld or the base metal, when heat is applied.

2.2 Welded connections of steel pipes

2.2.1 All welded butt joints shall normally be of the full penetration type. For class I and II pipes and important class III piping (see Table 4), special provisions shall be taken to ensure a high quality of the root side.

2.2.2 Branches shall be welded to the main pipe by means of full penetration welds. For class I and II pipes a welding procedure test (WPQT) may be required.

2.2.3 Joint preparation and alignment shall be in accordance with a recognised international standard.

2.2.4 If the parts to be joined differ in wall thickness, the thicker wall shall be gradually tapered to that of the thinner of the butt joint with a slope not steeper than 1:4.
2.2.5 Tack welding shall, when integrated in production weld, be carried out in accordance with approved WPS specifying the applied minimum welding length.

2.2.6 Tack welds, if retained as part of the welding process, shall be free from defects and provide adequate conditions for pass welding. Cracked tack welds shall not be welded over.

2.3 Pre-heating of steel pipes

2.3.1 Preheating of the different types of steel will be dependent upon their thickness and chemical composition as indicated in Table 1. Dryness shall be ensured using suitable preheating, if necessary.

2.3.2 The values in Table 1 are based on use of low hydrogen processes. Consideration should be given to using higher preheating temperatures when low hydrogen processes are not used.

Table 1 Preheating prior to welding of steel pipes

<table>
<thead>
<tr>
<th>Type of steel</th>
<th>Thickness of thicker part (mm)</th>
<th>Minimum preheating temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C and C/Mn steel</td>
<td>$\frac{C + Mn}{6} \leq 0.40$</td>
<td>$\geq 20$ 2)</td>
</tr>
<tr>
<td>C and C/Mn steel</td>
<td>$\frac{C + Mn}{6} &gt; 0.40$</td>
<td>$\geq 20$ 2)</td>
</tr>
<tr>
<td>0.3 Mo</td>
<td>$\geq 13$</td>
<td>100</td>
</tr>
<tr>
<td>1 Cr 0.5 Mo</td>
<td>$&lt; 13$</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$\geq 13$</td>
<td>150</td>
</tr>
<tr>
<td>2.25 Cr 1 Mo and 0.5Cr 0.5 Mo 0.25 V 1)</td>
<td>$&lt; 13$</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>$\geq 13$</td>
<td>200</td>
</tr>
</tbody>
</table>

1) Preheating of these materials may be omitted for thickness up to 6 mm subject to acceptable results of hardness tests carried out on welding procedure qualification
2) For welding in ambient temperature below 0°C, the minimum preheating temperature is required independent of the thickness unless specially considered.

2.3.3 Austenitic stainless steel shall not be preheated.

2.3.4 Where applied, the heating procedure and the temperature control shall be considered and provided as appropriate.

2.4 Heat treatment after welding of steel pipes

2.4.1 Where applied, the heat treatment shall be carried out in such a manner as to avoid impairment of the specified material properties.
2.4.2 The heat treatments shall preferably be carried out in suitable furnaces provided with temperature recording equipment. Where this is not practicable, localised heat treatments on a sufficient portion of the length in way of the welded joint, and carried out with approved procedures, may be applied. The width of the heated circumferential band shall be at least 75 mm on both sides of the weld. Special consideration shall be given to the placement of thermo-couples when heating welds adjacent to large heat sinks such as valves or fittings, or when joining parts of different thickness. In any case the soaking temperature shall not exceed the lower critical temperature of the material. Location of thermo-couples shall be shown in the heat treatment procedure as referred to in AWS D10.10 (Recommended Practices for Local Heating of Welds in Piping and Tubing)

Guidance note:
For austenitic stainless steel heat treatment after welding is not normally required.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.4.3 For other alloy steel grades the necessary heat treatment after welding shall be specially considered.

2.4.4 Stress relieving heat treatment shall be applied after welding, other than oxy-acetylene welding, as indicated in Table 3.

2.4.5 Heat treatment for oxy-acetylene welding shall be as indicated in Table 2, unless alternative treatment is clearly applicable.

Table 2 Full heat treatment after forming and welding

<table>
<thead>
<tr>
<th>Type of steel</th>
<th>Heat treatment and temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C and C/Mn Steel</td>
<td>Normalising 880 to 940</td>
</tr>
<tr>
<td>0.3 Mo</td>
<td>Normalising 900 to 940</td>
</tr>
<tr>
<td>1 Cr 0.5 Mo</td>
<td>Normalising 900 to 960</td>
</tr>
<tr>
<td></td>
<td>Tempering 640 to 720</td>
</tr>
<tr>
<td>2.25 Cr 1 Mo</td>
<td>Normalising 900 to 960</td>
</tr>
<tr>
<td></td>
<td>Tempering 650 to 780</td>
</tr>
<tr>
<td>0.5 Cr 0.5 Mo 0.25V</td>
<td>Normalising 930 to 980</td>
</tr>
<tr>
<td></td>
<td>Tempering 670 to 720</td>
</tr>
</tbody>
</table>

2.4.6 The stress relieving heat treatment shall consist of:
— heating the piping slowly and uniformly to a temperature within the range indicated in Table 3
— soaking at this temperature for a suitable period, in general one hour per 25 mm of thickness with minimum half an hour
— cooling slowly and uniformly in a furnace, to a temperature not exceeding 400°C; and subsequently
— cooling in still air.

2.4.7 In all cases, the heat treatment temperature shall not be higher than \( t_T - 20°C \) where \( t_T \) is the temperature of the final tempering treatment of the material.
Table 3 Stress relieving heat treatment after forming and welding

<table>
<thead>
<tr>
<th>Type of steel</th>
<th>Thickness of thicker part (mm)</th>
<th>Stress relief heat treatment temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C and C/Mn steel</td>
<td>≥ 15 1)3)</td>
<td>550 to 620</td>
</tr>
<tr>
<td>0.3 Mo</td>
<td>≥ 15 1)</td>
<td>580 to 640</td>
</tr>
<tr>
<td>1 Cr 0.5 Mo</td>
<td>&gt; 8</td>
<td>620 to 680</td>
</tr>
<tr>
<td>2.25 Cr 1 Mo and 0.5 Cr 0.5 Mo 0.25V</td>
<td>any 2)</td>
<td>650 to 720</td>
</tr>
</tbody>
</table>

1) The minimum thickness above which post weld heat treatment shall be applied may be increased for steel with specified Charpy notch impact properties, subject to special consideration.
2) Heat treatment may be omitted for pipes having thickness ≤ 8 mm, diameter ≤ 100 mm and minimum service temperature above 450°C, subject to special consideration.
3) For C and C-Mn steel, stress relieving heat treatment may be omitted up to 30 mm thickness subject to special consideration.

2.5 Non-destructive testing

2.5.1 Both sides of all welded piping joints shall be visually examined, wherever possible. Non-destructive testing (NDT) is required depending on the class of pipes and type of joints. These shall be applied as in Table 4.

Table 4 Non-destructive testing (NDT) requirements

<table>
<thead>
<tr>
<th>Piping class</th>
<th>Items to be inspected</th>
<th>Inspection method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>Butt welded pipes with an outer diameter &gt; 76.1 mm</td>
<td>100% radiographic testing (RT)</td>
</tr>
<tr>
<td></td>
<td>Butt welded pipes with an outer diameter ≤ 76.1 mm</td>
<td>10% radiographic testing (RT)</td>
</tr>
<tr>
<td></td>
<td>Fillet welded flange connections in pipes with an outer diameter &gt; 76.1 mm</td>
<td>100% magnetic particle testing (MT)</td>
</tr>
<tr>
<td></td>
<td>Fillet welded pipes with an outer diameter ≤ 76.1 mm</td>
<td>Random magnetic particle testing (MT)</td>
</tr>
<tr>
<td>Class II</td>
<td>Butt welded pipes with outer diameter &gt; 101.6 mm</td>
<td>At least 10% random radiographic testing</td>
</tr>
<tr>
<td></td>
<td>Fillet welded pipes with outer diameter &gt; 101.6 mm</td>
<td>Random magnetic particle testing (MT)</td>
</tr>
<tr>
<td>Class III</td>
<td>Fillet welds on safety critical piping with an outer diameter &gt; 101.6 mm</td>
<td>Random magnetic particle testing (MT)</td>
</tr>
<tr>
<td>Class III</td>
<td>Butt welded safety critical piping 1) such as fire extinction, cooling water, fuel oil, crude oil, bilge, ballast etc.</td>
<td>5% radiographic testing 2)</td>
</tr>
</tbody>
</table>

1) Criticality should be determined based on accessibility, possibility of local repair and consequence of associated downtime.
2) The extent of testing may be re-evaluated based on the result of the examination.
2.5.2 Heating coils in cargo tanks shall be subject to NDT in accordance with Table 5.

Table 5 Non-destructive testing (NDT) of heating coils

<table>
<thead>
<tr>
<th>Material in coils</th>
<th>Joint types</th>
<th>Butt welds(^1)</th>
<th>Sleeve or lap type welded or brazed joints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Erection welds</td>
<td>Shop welds</td>
<td>Erection joints</td>
</tr>
<tr>
<td>Mild steel</td>
<td>10%</td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>10%</td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td>Cu-Ni or Al-brass</td>
<td>10%</td>
<td>5%</td>
<td>Spot-check NDT, Steam testing onboard(^2)</td>
</tr>
</tbody>
</table>

Notes:
1) If automatic welding is used, the percentage may be reduced at the surveyors discretion.
2) Experience shows that pressure tests do not always reveal leaks in joints because a capillary gap can be temporarily sealed by flux residues. A recommended part of the procedure for testing a heating coil system should therefore be to apply a steam test, which shall dissolve flux residues and reveal leaks.

2.5.3 A recognised alternative ultrasonic testing (UT) procedure may upon special consideration be applied in lieu of radiographic testing provided the conditions are such that a comparable level of weld quality is assured.

When post weld heat treatment is required the final NDT should normally be performed after heat treatment.

2.5.4 For non-magnetic materials, dye-penetrant testing (PT) shall be used in lieu of magnetic particle examination.

2.5.5 Non-destructive testing shall be performed by operators certified in accordance with a recognised scheme, using suitable equipment and procedures. The radiographs shall be suitably marked to enable easy identification of the examination location on the pipe.

2.5.6 The results of radiographs shall be graded according to ISO 5817, and shall at least meet the requirements to quality level B for welds where a 100% radiographic testing is required, and to quality level C where a random testing is required.

2.5.7 The results from surface examination (e.g. MT, PT) shall meet the requirements of level B of ISO 5817.

2.5.8 The repair of defects revealed during non-destructive testing shall be carried out as appropriate. All such weld repairs shall be examined using the relevant testing method.

2.5.9 If a non-conforming discontinuity is detected, the lengths welded immediately before and after the section containing the discontinuity shall be examined by the same method. If systematically repeated discontinuities are revealed, the extent of testing shall be increased for welds manufactured under same conditions and where similar defects may be expected.
2.5.10 If non-conforming discontinuities are found to occur regularly, the welding procedures shall be reassessed before continuation of the welding, and necessary actions shall be taken to bring the production to the required quality level.
Detected non-conforming discontinuities shall be repaired unless they are found acceptable. Removal of weld discontinuities and repair shall be performed in accordance with an approved procedure.

3 Brazing of copper and copper alloys

3.1 General

3.1.1 Close joint brazing shall be used. The clearance between surfaces to be joined shall not be larger than necessary to ensure complete capillary distribution of the filler metal.

3.1.2 The suitability of filler metal and flux shall be considered. The filler metal is to have a melting point above 450°C.

4 Pipe bending

4.1 General

4.1.1 The bending procedure shall be such that flattening of the pipe cross-section is as small as possible.

Interpretation:
For class I and II pipes the out-of-roundness, \( \eta \) should not exceed 7% where \( \eta \) is defined by:

\[
\eta = \frac{D_{\text{max}} - D_{\text{min}}}{D_{\text{max}} + D_{\text{min}}} \cdot 100\% 
\]

\( D \) = outer pipe diameter.

---end---of---i-n-t-e-r-p-r-e-t-a-t-i-o-n---

4.1.2 Pipe bends in class I and II pipes shall be free from wrinkles on the inner side of the bend.

4.1.3 Copper alloy pipes in seawater systems shall be free from wrinkles as far as possible.

4.1.4 For tolerances in wall thickness and allowance for bending, see Sec.2 [3.4.7] and Sec.2 [3.4.15].

4.2 Heat treatment after bending

4.2.1 Hot forming shall normally be carried out in the temperature range 850°C to 1000°C for all material grades.
However, a temperature decrease to 750°C is allowable during the forming process. When the hot forming is carried out within this temperature range, the following requirements generally apply:
— for C, C-Mn and C-Mo steel, no subsequent stress relieving heat treatment is required
— for Cr-Mo and Cr-Mo-V steel, a subsequent stress relieving heat treatment in accordance with Table 2 is required
— for other alloy steel heat treatment after bending will be considered in each case.
4.2.2 When hot forming is performed outside the above temperature range, a subsequent new heat treatment in accordance with Table 2 is required for all grades.

4.2.3 The need for complete heat treatment (Table 2) after cold forming, when \( r \leq 2.5 \, D \) (where \( r \) is the mean bending radius and \( D \) is the outside diameter of pipe) shall be considered. At minimum, stress relieving heat treatment in accordance with Table 3 is required for all grades other than carbon-manganese steel with \( R_m \leq 410 \, (N/mm^2) \).

4.2.4 Aluminium-brass pipes shall be stress-relieved or soft annealed at a temperature of 350 to 400°C or 600 to 650°C respectively, after cold working.

4.2.5 Normalising shall usually be performed in a furnace. Stress-relief may be performed locally covering the deformed zone. Method of heat-treatment and temperature control shall be according to recognised codes.

4.2.6 Hot forming of austenitic stainless steel shall be carried out in the temperature range 850 to 1150°C. Cold forming may be carried out when \( r \geq 2.5 \, D \) (where \( r \) is the mean bending radius and \( D \) is the outside diameter of pipe).

5 Joining of plastic pipes

5.1 General

5.1.1 Joining or bonding of plastic pipes by welding, gluing, lamination or similar method shall be undertaken by qualified personnel and in accordance with the pipe manufacturer’s recommendations.

5.1.2 Before installation, all piping components shall be visually inspected for damage that may have occurred during shipment. Pipes with burns, cracks and rupture of the laminate with complete penetration should be rejected.

5.2 Installer certification

5.2.1 With respect to joining or bonding of plastic pipes, all personnel shall be given theoretical and practical training followed by a written examination and a practical test.

5.2.2 Certificate for joining or bonding of plastic pipes shall contain the following information:

- the name of the holder
- the type of joining for which the holder is qualified
- reference to joining or installation procedure (procedure date of issue to be stated)
- date of issue and validity period for certificate, and
- pipe manufacturer's stamp and signature.

5.2.3 In addition to being certified, each joining or bonding operator shall make a test assembly consisting of one pipe-to-pipe joint and one pipe-to-fitting joint in accordance with joining or bonding procedure qualified according to [5.2.4] and [5.2.5].
5.2.4 **Procedure qualification testing**

1) Each joining or bonding operator shall make a test assembly fabricated in accordance with the joining or bonding procedure to be qualified, consisting of at least:
   - one pipe-to-pipe joint
   - one pipe-to-fitting joint.

2) After curing, the assembly shall be subjected to a hydrostatic test pressure at a safety factor of 2.5 times the nominal pressure rating (pressure class) of the piping system. The test duration shall be minimum 1 hour.

3) Acceptance criteria: No leakage or separation of joints.

5.2.5 Pipe size for procedure qualification test assembly shall be:

   - when the largest size to be joined is ≤ 200 mm nominal outside diameter, the test assembly shall be the largest piping size to be joined.
   - when the largest size to be joined is > 200 mm, the size of the test assembly shall be either 200 mm or 25% of the largest piping size to be joined, whichever is greater.

5.3 **Installation**

5.3.1 Jointing and installation of piping components shall be carried out according to manufacturer recommendations, such that they are stress free.

5.3.2 Bending of pipes to achieve changes in direction, or forcing misaligned flanges together by overtorqueing bolts shall not be performed.

5.3.3 The joining or bonding procedure shall include:

   - materials and suppliers
   - tools and equipment
   - environmental requirements
   - joint preparation including surface treatment and cleanliness
   - dimensional requirements and tolerances
   - curing time and temperature
   - tests and examinations with acceptance criteria.

5.3.4 Any change in the joining or bonding procedure which may affect the physical or mechanical properties of the joint or bond shall require re-qualification of the procedure.

5.3.5 The pipe manufacturer shall maintain a record of earlier certifications of procedures and operators.

5.4 **Electrical conductivity**

5.4.1 Piping systems in or through gas hazardous areas carrying fluids capable of generating electrostatic charges shall be electrically conductive according to Sec.2 [3.8.9].

5.4.2 After installation, the conductivity of the piping system shall be measured, and the resistance to earth from any point in the piping system shall not exceed $10^6$ ohm.
5.5 Quality control

5.5.1 The quality control shall be based on the implementation of:
— bonding procedure qualification records
— inspection of adhesive-bonded joints
— inspection register for piping joints
— inspection of finished fabricated pipework for compliance with design drawings.

5.5.2 Each adhesive-bonded connection shall be permanently marked for identification purposes. A log book containing the following key values relevant for the bonding process shall be maintained:
— date
— temperature and relative humidity
— identification number
— curing temperature and time
— signature of the quality inspector.

5.6 Pressure testing of plastic pipes

5.6.1 All closed GRP or GRE piping systems shall be hydrostatically pressure tested after installation. Systems which are open to atmosphere (e.g. drains) shall be subject to a hydrostatic leak test as minimum.

5.6.2 The test pressure shall be raised slowly to 1.5 times the design pressure and conducted for a minimum of one hour. There shall be no leaking or weeping of the system during the test.

6 Hydrostatic tests of piping

6.1 Hydrostatic testing before assembly on board

6.1.1 All class I and II pipes and integral fittings shall be subjected to a hydrostatic test after completion of manufacturer but before insulation and coating, if any. The hydrostatic test shall be at the following pressure:

\[ P_H = 1.5 \ p \]

\( P_H \) = test pressure in bar
\( p \) = design pressure in bar as defined in Sec.2 [3.4.3]

For steel pipes and integral fittings for design temperatures above 300°C the test pressure shall be determined by the following formula but need not exceed 2 \( p \):

\[ P_H = 1.5 \frac{\sigma_{100}}{\sigma_t} \ p \]

\( \sigma_{100} \) = permissible stress at 100°C.
\[ \sigma_t = \text{permissible stress at the design temperature.} \]

**Guidance note:**
Where necessary, the value of the test pressure may be reduced to 1.5 \( p \) in order to avoid excessive stress in way of bends, branches etc. In any case the membrane stress is not to exceed 0.9 the yield stress at the testing temperature.

---end---of---guidance---note---

**Guidance note:**
Pressure testing of small bore pipes (less than 15 mm D) need not be undertaken where not considered appropriate with respect to the application.

---end---of---guidance---note---

6.1.2 Non-integral fittings and pressure containing components other than valves, pump housing and pressure vessels shall be tested as specified in [6.1.1].

6.2 Hydrostatic testing after assembly on board

6.2.1 The piping shall be hydrostatically tested in accordance with Table 6.

**Table 6 Hydrostatic testing after assembly on board**

<table>
<thead>
<tr>
<th>Piping system</th>
<th>Test pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel oil piping</td>
<td>1.5 x design pressure, minimum 4 bar</td>
</tr>
<tr>
<td>Heating coils in tanks</td>
<td></td>
</tr>
<tr>
<td>Bilge, ballast and fire pipes</td>
<td>1.5 x design pressure</td>
</tr>
<tr>
<td>Class III pipelines for steam, compressed air and feed water</td>
<td>1.5 x design pressure, minimum 4 bar, minimum duration 1 hour</td>
</tr>
<tr>
<td>Hydraulic piping</td>
<td>1.5 x design pressure. Test pressure need not exceed design pressure by more than 70 bar</td>
</tr>
<tr>
<td>Piping systems made from non-metallic material</td>
<td>1.5 x design pressure, minimum 4 bar, minimum duration 1 hour</td>
</tr>
<tr>
<td>Refrigeration piping(^1)</td>
<td>1.5 x design pressure</td>
</tr>
</tbody>
</table>

\(^1\) Hydraulic pressure tests may be carried out with any liquid, including water, unless it has an unfavourable effect on the refrigerant. Pneumatic pressure tests may be carried out with nitrogen, CO\(_2\) or air.

6.2.2 If pipes specified in [6.1.1] shall be welded together during assembly on board, they shall be hydrostatically tested after welding. Hydraulic testing may not be required where a 100% radiographic examination and heat treatment after welding is carried out, and indicates acceptable results.

**Guidance note:**
Separate pipe lengths which have been hydraulically tested in the workshop may be insulated before the hydrostatic test is carried out, except for connections between the pipe lengths.

---end---of---guidance---note---
7 Functional testing

All piping systems shall be properly flushed, checked for leakage and functionally tested under working conditions.

**Guidance note:**

It is recommended not to use sea water for flushing of stainless steel pipes.

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CHAPTER 3 CERTIFICATION AND CLASSIFICATION

SECTION 1  CLASSIFICATION

1 Classification

1.1 Introduction

1.1.1 As well as representing DNV GL’s recommendations on safe engineering practice for general use by the offshore industry, the offshore standards also provide the technical basis for DNV GL classification, certification and verification services.

1.1.2 This chapter identifies the specific documentation, certification and surveying requirements to be applied when using this standard for certification and classification purposes.

1.1.3 A complete description of principles, procedures, applicable class notations and technical basis for offshore classification is given by the DNV GL rules for classification of offshore units as listed in Table 1.

Table 1 DNV GL rules for classification - Offshore units

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNVGL-RU-OU-0101</td>
<td>Offshore drilling and support units</td>
</tr>
<tr>
<td>DNVGL-RU-OU-0102</td>
<td>Floating production, storage and loading units</td>
</tr>
<tr>
<td>DNVGL-RU-OU-0103</td>
<td>Floating LNG/LPG production, storage and loading units</td>
</tr>
<tr>
<td>DNVGL-RU-OU-0104</td>
<td>Self-elevating units</td>
</tr>
<tr>
<td>DNVGL-RU-OU-0375</td>
<td>Diving systems</td>
</tr>
<tr>
<td>DNVGL-RU-OU-0503</td>
<td>Offshore fish farming units and installations</td>
</tr>
</tbody>
</table>

1.2 Applicable requirements

Requirements as covered by classification are governed by class notations. A complete description of these and their related scope can be found in the above listed rules.

1.3 Application

1.3.1 Where codes and standards call for the extent of critical inspections and tests to be agreed between contractor or manufacturer and client, the resulting extent is to be agreed with DNV GL.

1.3.2 DNV GL may accept alternative solutions found to represent an overall safety level equivalent to that stated in the requirements of this standard.

1.3.3 Any deviations, exceptions and modifications to the design codes and standards given as recognised reference codes shall be approved by DNV GL.
1.4 Documentation

1.4.1 General
Documentation requirements for classification shall be in accordance with DNVGL-RU-SHIP Pt.1 Ch.3

1.4.2 Jacking systems
For jacking systems the following documents shall be provided:
- description and general layout plans of the jacking system
- rack and pinion system:
  - detailed drawings of gear elements
  - detailed drawings of rack and pinion with tooth geometry
  - drawings of power transmitting parts, shafts, bearings, couplings and casings, brakes
  - foundation drawings for the gears system drawings of hydraulic systems, if applicable
  - single line diagram for electric system, if applicable
  - gear data sheet (see DNV GL Form 71.10a)
- rack and pinion system:
  - detailed drawing of hydraulic cylinders and control valves as required by Ch.2 Sec.4 [8].
  - details of pins and their activating mechanism
  - details of the leg chord pin holes
  - system diagram of the hydraulic system
  - details of the hydraulic power pack(s)
  - casing and supporting structure of the system including fixed and movable crossheads
- rubber block friction system:
  - system diagrams of pneumatic and hydraulic systems, if applicable
  - detailed calculations and drawings of the rubber block system to create friction
  - detailed drawings of the ring structure connected to the rubber blocks
  - detailed drawing of hydraulic and pneumatic cylinders and control valves, if applicable
  - details of hydraulic power packs and compressors
  - details of air reservoirs
  - casing and support structure of the system including fixed and movable crossheads and grippers
- details of electrical installation documentation as applicable according to DNVGL-OS-D201
- operating, control and monitoring system documentation as described in DNVGL-OS-D202
- design calculations
- description and design drawings of blocking system, e.g. rack and chock system:
  - detailed drawings of the chocks with holding teeth
  - detailed drawings of chock activator
  - details of the hydraulic lifting system
  - details of the hydraulic power pack(s).
SECTION 2 CERTIFICATION OF MATERIALS AND COMPONENTS

1 Principles

1.1 General

1.1.1 Marine and machinery systems and components shall be certified or classified based on the following main activities:
— design verification
— equipment certification
— survey during construction and installation, and
— survey during commissioning and start-up.

1.1.2 Certification is a conformity assessment normally including both design and production assessment. The production assessment includes inspection and testing during production and/or of the final product.

1.1.3 Components shall be certified consistent with their function and importance for safety. The principles of categorisation of component certification are given in the relevant DNV GL rules for classification of offshore units, see Sec.1 Table 1.

1.1.4 Manufacturers of pressure equipment as specified in Table 2 and as listed below shall be approved by DNV GL in accordance with DNVGL-RP-0261 Pressure equipment.
— welded pressure equipment
— pressure equipment with pressed parts manufactured by the pressure equipment manufacturer.
— pressure equipment where heat treatment is necessary in the manufacturing process.
— seamless gas cylinders.

1.2 Compliance document types

1.2.1 General
A compliance document is a statement:
— relating to an object
— validated and signed by the issuing organisation
— stating that the object complies with the requirements of the parts of the standards and their editions, as referred to in the compliance document
— based on design assessment and/or audit and/or survey performed by an authorised representative of the issuing organisation or by other means accepted by the issuing organisation.

1.2.2 Product certificate (PC)
A compliance document validated and signed by the issuing organisation:
— identifying the product that the certificate applies to
— confirming compliance with referred requirements.

It is required that:
— the tests and inspections have been performed on the certified product itself, or on samples taken from the certified product itself
— the tests were witnessed by a qualified representative of the organisation issuing the certificate, or his authorized representative.
1.2.3 Material certificate (MC)
A compliance document, validated and signed by the issuing organization, stating:
— that the material of the product conforms with the requirements referred to in the certificate
— results of specific inspection

1.2.4 DNV GL certificate (VL)
A product or material certificate confirming compliance with this standard, validated and signed by a DNVGL surveyor will be denoted a VL certificate

1.2.5 Works certificate (W)
A product or material certificate issued by the manufacturer and confirming compliance with this standard is named works certificates (W).

1.2.6 DNVGL type approval certificate (TA)
A document issued by DNVGL confirming compliance with this standard is named a DNVGL type approval certificate (TA)

1.2.7 Test report (TR)
A document signed by the manufacturer stating:
— that the object complies with this standard
— that tests are carried out on samples from the current production.

1.3 Type approval

1.3.1 Type approval is a procedure for approval of standard designs and/or routinely manufactured, identical components to be used in DNV GL classed objects. Type approval can be applied to:
— products
— group of products
— systems.

1.3.2 The type approval procedure may consist of the following elements:
— design assessment
— initial survey
— type testing
— issuance of type approval certificate.
The type approval procedure used by DNVGL is described in DNVGL-CP-0338.

1.3.3 When the type approval procedure is used, the following shall be submitted for approval as required in type approval programs and applicable chapters of this standard
— documentation of the design
— results of type testing normally witnessed by a DNVGL surveyor
A type approval certificate will be issued by DNVGL when compliance with the design requirements is confirmed.

1.3.4 For certain products and systems, as defined in applicable DNV GL offshore standards, only type approval is required. For these products and systems no survey is required, i.e. no product certificate is required.
1.4 Categorisation of equipment and components

Equipment is categorised based on safety and complexity considerations. The category of equipment will determine the scope of the certification activity and the certificate type to be issued.

1.5 Certification requirements under this standard

1.5.1 Certification requirements for miscellaneous mechanical components are given in Table 1.

### Table 1 Certification of miscellaneous machinery and mechanical components

<table>
<thead>
<tr>
<th>Item</th>
<th>Certificate type</th>
<th>Issued by</th>
<th>Certification standard</th>
<th>Additional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jacking machinery</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turret bearings</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boiler</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condenser</td>
<td>W</td>
<td>Manufacturer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boiler heat exchanger</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumps for boiler</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boiler PSV</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boiler spark arrestor</td>
<td>TR</td>
<td>Manufacturer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winches</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic Cylinders</td>
<td>PC</td>
<td>Society</td>
<td>DNVGL-CG-0194</td>
<td>For cylinders where PD&gt;20 000.</td>
</tr>
<tr>
<td>Hydraulic cylinders for cleating and manoeuvring of watertight doors and hatches</td>
<td>PC</td>
<td>Society</td>
<td>DNVGL-CG-0194</td>
<td>All cylinders regardless of pressure and size.</td>
</tr>
<tr>
<td>Cleating cylinders where the locking mechanism is placed inside the cylinder</td>
<td>TA</td>
<td>Society</td>
<td>DNVGL-CG-0194</td>
<td></td>
</tr>
<tr>
<td>Compressor(^1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Unless otherwise specified the certification shall be according to the applicable DNVGL rules and standards.

2) Compressors to be certified in accordance with DNVGL-RU-SHIP Pt.4 Ch.5 Sec.4.

P = design pressure (bar)

D = internal diameter of cylinder tube (mm)

1.5.2 Piping and piping components shall be delivered with material certification in accordance with Ch.2 Sec.2 Table 5. Where the table require certificate type 3.2 this shall be carried out by DNV GL (VL certificate). Where the table require certificate type 3.1 this shall be a works certificate (W) from a DNVGL approved mill.

1.5.3 Certification requirements for pressure vessels are given in Table 2.
Table 2 Categories for pressure containing equipment and storage vessels 1)

<table>
<thead>
<tr>
<th>Property</th>
<th>Conditions</th>
<th>Certificate type</th>
<th>Issued by</th>
<th>Certification standard 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>Pressure vessels, including mountings, necessary for performing the main functions listed in documents referred to in Sec.1 Table 1</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td>Vacuum or external pressure</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Steam</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toxic fluid</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermal oil</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liquids with flash point below 100°C</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flammable fluids with T &gt; 150°C</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other fluids with T &gt; 220°C</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compressed air/gas PV ≥ 1.5</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>$\sigma_y$ 345 MPa (50000 psi) or $\sigma_t$ 515 MPa (75000 psi)</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Where impact testing is required</td>
<td>PC</td>
<td>Society</td>
<td></td>
</tr>
</tbody>
</table>

1) Unless otherwise specified the certification shall be according to the applicable DNVGL rules and standards.
2) Free standing structural storage tanks will be specially considered based on stored medium, volume and height. These may be designed according to the requirements of DNVGL-OS-C101.

\[ P = \text{internal design pressure in bar} \]
\[ D_i = \text{inside diameter in mm} \]
\[ V = \text{volume in m}^3 \]
\[ T = \text{design temperature} \]
\[ \sigma_y = \text{specified yield strength} \]
\[ \sigma_t = \text{specified ultimate tensile strength} \]

1.5.4 Certification requirements for steering and propulsion components are given in Table 3.

Table 3 Certification of components for steering and propulsion systems

<table>
<thead>
<tr>
<th>Item</th>
<th>Certificate category</th>
<th>Issued by</th>
<th>Certification standard 1)</th>
<th>Additional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thruster including receptacles</td>
<td></td>
<td></td>
<td>See DNVGL-RU-SHIP Pt.4 Ch.5</td>
<td></td>
</tr>
<tr>
<td>Propeller</td>
<td></td>
<td></td>
<td>See DNVGL-RU-SHIP Pt.4 Ch.5</td>
<td></td>
</tr>
<tr>
<td>Steering gear</td>
<td></td>
<td></td>
<td>See DNVGL-RU-SHIP Pt.4 Ch.10</td>
<td></td>
</tr>
<tr>
<td>Rudder</td>
<td></td>
<td></td>
<td>See DNVGL-RU-SHIP Pt.3 Ch.14</td>
<td></td>
</tr>
</tbody>
</table>
1.5.5 Certification of components in marine piping systems are given in Table 4.

1.5.6 Electrical equipment shall be certified in accordance with DNVGL-OS-D201 Ch.3 Sec.1 [3.4].

Table 4 Certification of components in marine piping systems

<table>
<thead>
<tr>
<th>Item</th>
<th>Certificate type</th>
<th>Issued by</th>
<th>Certification standard 1)</th>
<th>Additional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea-water cooling pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>For main power and propulsion drivers</td>
</tr>
<tr>
<td>Fresh-water cooling pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>For main power and propulsion drivers</td>
</tr>
<tr>
<td>Circulating pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>For boilers with forced circulation and main condenser</td>
</tr>
<tr>
<td>Air pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>For main condenser</td>
</tr>
<tr>
<td>Feed water pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensate pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>For main condenser</td>
</tr>
<tr>
<td>Fuel oil pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>Transfer, booster, service and fuel injection valve cooling pumps</td>
</tr>
<tr>
<td>Lubricating oil pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>Propulsion drivers, trusters and reduction gears</td>
</tr>
<tr>
<td>Bilge pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>Bilge pumps additional to the ones required by the rules need not be certified.</td>
</tr>
<tr>
<td>Ballast pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire water pumps</td>
<td></td>
<td></td>
<td></td>
<td>See DNVGL-OS-D301 Ch.3 Sec.1</td>
</tr>
<tr>
<td>Hydraulic pumps</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>For gears, windlasses, variable pitch propellers, side thrusters and hydraulically operated valves</td>
</tr>
<tr>
<td>Thermal oil circulation pump</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Certificate type</td>
<td>Issued by</td>
<td>Certification standard</td>
<td>Additional description</td>
</tr>
<tr>
<td>------</td>
<td>------------------</td>
<td>-----------</td>
<td>------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Other pumps considered necessary for performing the main functions</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Main function as defined in the relevant DNVGL-RU-OU, see Sec.1 Table 1</td>
</tr>
<tr>
<td><strong>Fans</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Force draft fans</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>Propulsion boilers</td>
</tr>
</tbody>
</table>
| Ventilation fans | PC | Society | | Serving hazardous spaces  
For battery rooms, paint stores and gas bottle stores, a certificate from a notified body, showing compliance with EN 13463-1, EN 13463-5 and EN14986, together with manufacturers works certificate may replace a Society product certificate. |
| **Valves** | | | | Nominal diameter > 100 mm and design pressure ≥ 16 bar. |
| Valves | PC | Society | | |
| Ship side valves | PC | Society | | Nominal diameter > 100 mm |
| Other valves | PC | Manufacturer | | |
| Vent heads | TA | Society | DNVGL-CP-0187 | |
| Pressure relief valves | W | Manufacturer | | Compressed air |
| **Flexible hoses** | | | | |
| Flexible hoses with couplings | TA | Society | DNVGL-CP-0183 | |
| **Plastic piping** | | | | |
| Plastic piping | TA | Society | | |
| **Pipe couplings** | | | | For other than flanges |
| Pipe couplings | TA | Society | | |
| Expansion bellows | TA | Society | | For rubber compensators, see DNVGL-CP-0183 [3.5] |
| **Exhaust gas cleaning systems** | | | | See DNVGL-RU-SHIP Pt.4 Ch.6 Sec.1 Table 4 |
| Exhaust gas cleaning systems for NO\textsubscript{x} and SO\textsubscript{x} | | | | |
| **Hydraulic control of safety critical valves etc.** | | | | |
| Hydraulic control panel | PC | Society | | |


Marine and machinery systems and equipment

DNV GL AS
<table>
<thead>
<tr>
<th>Item</th>
<th>Certificate type</th>
<th>Issued by</th>
<th>Certification standard 1)</th>
<th>Additional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic power pack</td>
<td>W</td>
<td>Manufacturer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanks for hydraulic fluid</td>
<td>TR</td>
<td>Manufacturer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Unless otherwise specified the certification shall be according to the applicable DNVGL rules and standards.

Table 5 Certification of control and monitoring systems

<table>
<thead>
<tr>
<th>Item</th>
<th>Certificate category</th>
<th>Issued by</th>
<th>Certification standard 2)</th>
<th>Additional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steering systems (if relevant)</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>See DNVGL-RU-SHIP Pt.4 Ch.10</td>
</tr>
<tr>
<td>Propulsion systems (if relevant)</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>See DNVGL-RU-SHIP Pt.4 Ch.5</td>
</tr>
<tr>
<td>Main engine or main power</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>See DNVGL-RU-SHIP Pt.4 Ch.3</td>
</tr>
<tr>
<td>Emergency power</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>See DNVGL-RU-SHIP Pt.4 Ch.3</td>
</tr>
<tr>
<td>Ballast system</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilge system</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level monitoring</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>Applicable for — integrated tanks in columns and pontoons of column stabilised units — systems as listed in DNVGL-RU-SHIP Pt.5 Ch.5 Sec.1 Table 7</td>
</tr>
<tr>
<td>Control of safety critical valves</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jacking machinery (if installed)</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boiler (if installed)</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>Only if required by class notation, e.g. POSMOOR</td>
</tr>
<tr>
<td>Winches</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leak detection system</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td>If relevant for the unit, see also Ch.2 Sec.3 [6.5.10]</td>
</tr>
</tbody>
</table>

1) For other systems with similar application as for ships, certification requirements as given in relevant DNVGL-RU-SHIPs shall be applied.

2) Unless otherwise specified the certification shall be according to the applicable DNV GL rules and standards.
SECTION 3 SURVEYS

1 Survey during construction

1.1 General

1.1.1 This subsection describes surveys during construction of marine and machinery systems and components.

1.1.2 General requirements for surveying during construction are stated in the relevant DNV GL rules for classification of offshore units, see Sec.1 Table 1.

1.2 Quality assurance and quality control

1.2.1 The contractors shall operate a quality management system applicable to the scope of their work. The system shall be documented and contain descriptions and procedures for quality critical aspects.

1.2.2 Contractors who do not meet the requirement in [1.2.1] shall be subject to special consideration in order to verify that products satisfy the relevant requirements.

1.2.3 The contractors shall maintain a traceable record of non-conformities and corrective actions and make this available to the DNV GL surveyor on request.

   Guidance note:
   Contractors are encouraged to obtain ISO 9000 series quality system certification through DNV GL Accredited Quality System Certification services.

1.3 Materials

For material requirements, see Ch.2 Sec.2 [2].

1.4 Welding and welder qualification

1.4.1 Approval of welders shall be in accordance with DNVGL-OS-C401 or the applied design code.

1.4.2 Welders already approved to another corresponding code than the design code may be accepted if properly documented.

1.4.3 WPS shall be approved by DNV GL.

1.4.4 The extent of the welding procedure test shall be agreed upon with DNV GL before the work is started.

1.4.5 A welding production test (WPT) may be required by the surveyor during fabrication to verify that the produced welds are of acceptable quality.

1.4.6 Welding repairs shall be performed according to an repair procedure approved by DNV GL.
1.4.7 Socket welded joints and slip on sleeves shall be subject to special DNV GL approval on a case by case basis.

1.4.8 Local PWHT may be performed on simple joints when following an approved procedure. The procedure shall be approved by DNV GL.

1.4.9 The heat treatment procedure in connection with forming and/or welding shall be approved if not covered by the applied code or standard. Welding consumables shall be suitable for PWHT.

1.4.10 The heat treatment procedure in connection with pipe bending shall be approved if not covered by the applied code or standard.

1.4.11 Omission of heat relieving treatment for C and C-Mn steels up to 30 mm thickness shall be subject to special DNV GL approval.

1.4.12 Magnetic particle inspection (MPI) is the preferred method for detection of surface defects, however the liquid penetrant method may be used as an alternative, subject to DNV GL's acceptance in each case.

1.4.13 Piping systems shall be cleaned (e.g. by flushing, retro-jetting, chemical cleaning etc.) to remove debris or foreign bodies prior to start-up of sensitive equipment like pumps, compressors, isolation valves etc. The procedure and acceptance criteria shall be agreed with the surveyor.

2 Survey during installation and commissioning

2.1 General
Commissioning shall be in accordance with submitted procedures reviewed by DNV GL in advance of the commissioning. Commissioning shall be witnessed by a surveyor and is considered complete when all systems, equipment and instrumentation are operating satisfactorily. The intention of DNV GL's involvement in evaluation of commissioning procedures and attending commissioning of systems is to ensure that relevant equipment/systems is functioning in compliance with relevant Rules and Standards.

2.2 Mechanical completion
Before commissioning of systems starts, all items of pipework and equipment shall be checked for compliance with approved documentation and commissioning procedures.

2.3 Functional testing
During commissioning, the systems shall be functionally tested, as practicable in accordance with reviewed procedures.

2.4 Specific requirements for jacking systems

2.4.1 General
The testing of the jacking gear system shall in general consist of workshop testing, inspection after installation and testing on board.

2.4.2 Workshop testing
Spin test and contact pattern test shall be carried out according to DNVGL-RU-SHIP Pt.4 Ch.4 Sec.2 [4].
2.4.3 Installation inspection
The alignment between the pinions and rack shall be checked both longitudinally and with regard to distance between pinion centre and rack.
The gearing box shall be inspected on the following (see DNVGL-RU-SHIP Pt.4 Ch.4 Sec.2 [8]):
— shaft alignment, see DNVGL-RU-SHIP Pt.4 Ch.2 Sec.4
— fastening of propulsion gearboxes (stoppers and bolt tightening)
— flushing, applicable if the system is opened during installation. Preferably with the foreseen gear oil. If flushing oil is used, residual flushing oil shall be avoided.
— lubrication oil shall be as specified (viscosity and FZG class) on maker’s list
— pressure tests to nominal pressure (for leakage) where cooler, filters or piping is mounted onboard
— tooth contact pattern.

2.4.4 Jacking trials
Jacking trial shall be performed according to an approved jacking trial plan and as covered by the quality survey plan, see DNVGL-CG-0169. The trial shall cover the correct functioning of the jacking machinery and other relevant items.
The jacking machinery shall be tested with the maximum elevated weight and maximum pre-load. The duration shall at least reflect one operating cycle from transit condition to the top of the legs and down again.
The jacking trial shall verify the alignment of the racks and pinions and guides.
The following systems shall be tested:
— Jacking brake arrangement.
— Alarm and monitoring arrangement for the jacking machinery, supporting equipment and unit safety during jacking.
— Fail safe arrangement of the jacking machinery and any interlock safety arrangement.
— Essential systems and equipment used for normal jacking operations.
After trials, the structure including leg footing connection, guides, jack houses, jacking gear arrangement shall be surveyed to the satisfaction of the surveyor.
CHANGES – HISTORIC

July 2015 edition

Main changes July 2017

• General
The revision of this document is part of the DNV GL merger, updating the previous DNV standard into a DNV GL format including updated nomenclature and document reference numbering, e.g.:
— Main class identification 1A1 becomes 1A.
— DNV replaced by DNV GL.
— DNV-RP-A201 to DNVGL-CG-0168. A complete listing with updated reference numbers can be found on DNV GL’s homepage on internet.
To complete your understanding, observe that the entire DNV GL update process will be implemented sequentially. Hence, for some of the references, still the legacy DNV documents apply and are explicitly indicated as such, e.g.: Rules for Ships has become DNV Rules for Ships.

• Ch.2 Sec.5 Machinery and mechanical equipment
— See Sec.5 [3.1.2]: Including jacking fixation system in items described by the DNVGL-OS-C104 and DNVGL-OS-C201.
— See Sec.5 [3.2.8]: Including 'single' in “In case of single failures”.
— See Sec.5 [3.3.2]: Removing requirements to efficiency.
About DNV GL
Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping our customers make the world safer, smarter and greener.