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
General

This document supersedes DNV-OS-D101, October 2014.

Text affected by the main changes in this edition is 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.

On 12 September 2013, DNV and GL merged to form DNV GL Group. On 25 November 2013 Det Norske Veritas AS became the 100% shareholder of Germanischer Lloyd SE, the parent company of the GL Group, and on 27 November 2013 Det Norske Veritas AS, company registration number 945 748 931, changed its name to DNV GL AS. For further information, see www.dnvgl.com. Any reference in this document to "Det Norske Veritas AS", “Det Norske Veritas”, “DNV”, “GL”, “Germanischer Lloyd SE”, “GL Group” or any other legal entity name or trading name presently owned by the DNV GL Group shall therefore also be considered a reference to “DNV GL AS”.

Main changes July 2014

- **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**
  - [3.1.2]: Including jacking fixation system in items described by the OS-C104 and C201.  
  - [3.2.8]: Including 'single' in “In case of single failures”.  
  - [3.3.2]: Removing requirements to efficiency.

Editorial corrections

In addition to the above stated main changes, editorial corrections may have been made.
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CHAPTER 1 GENERAL

SECTION 1 INTRODUCTION

1 General

1.1 Introduction

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

1.1.2 The requirements of this standard are in compliance with relevant parts of SOLAS Ch. II-1 and the IMO MODU Code.

SOLAS references are as quoted in MODU Code 2009 and fulfil class requirements. Note that for compliance with flag state requirements, later amendments may be applicable.

1.1.3 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.

1.2 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
— 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 requirements in this standard cover marine piping systems, machinery piping systems and marine machinery systems, which are defined as systems serving the marine systems on a 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 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 DNV Rules for ships Pt.5 Ch.3. The additional requirements to class III piping in this standard shall be applied.

1.3.3 Reference to DNV Rules for ships is conditioned that there is no coincident 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 8 as applicable.

Guidance note:
Some systems used for typical tank ship applications, (e.g. cargo piping, ballast systems, firewater systems), need to 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.

---e-n-d-o-f---g-u-i-d-a-n-c-e---n-o-t-e---
1.3.4 Piping and equipment in connection with LNG storage are addressed in DNV-OS-C503 Concrete LNG Terminal Structure and Containment Systems and DNV Rules for ships Pt.5 Ch.5.

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

1.4 Application

1.4.1 Interpretations
This standard has been based on international 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 DNV GL interpretation has been added.

1.4.2 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.

1.4.3 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.

1.4.4 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 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>
</tbody>
</table>

1.4.5 The scope of classification may be extended by the voluntary notation ES. The applicable sections or requirements as indicated accordingly shall only be enforced in case this notation is part of this extended classification scope (see also, Ch.3 Sec.1 [1.2]).

1.4.6 The requirements of this standard are applicable for mobile offshore 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.

1.4.7 The requirements of this standard may also be applied to equivalent areas of fixed offshore installations.

1.4.8 Units or installations with ballast water treatment systems installed in order to meet the requirements of the Ballast Water Management Convention shall follow the requirements of DNV Rules for ships Pt.6 Ch.18 Sec.4.

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 DNV GL and DNV publications are given in Table 2.

Table 2 DNV and DNV GL reference documents

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNVGL-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-CG-0168</td>
<td>Plan approval documentation types – definitions</td>
</tr>
<tr>
<td>DNV TAP 5-792.20</td>
<td>DNV Type Approval Programme - Pipe Couplings</td>
</tr>
<tr>
<td>DNV Rules for ships</td>
<td>Rules for Classification of Ships</td>
</tr>
<tr>
<td>DNV Classification Note 41.2</td>
<td>Calculation of Gear Rating for Marine Transmissions</td>
</tr>
</tbody>
</table>

2.2.2 Other reference documents are given in Table 3 and in Ch.2 Sec.5 [2].

Table 3 Normative references

<table>
<thead>
<tr>
<th>Reference</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 Units2009</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>
<tr>
<td>SOLAS</td>
<td>1974 SOLAS International Convention for the Safety of Life at Sea 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 4.

Table 4 Informative references

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASME B31.3</td>
<td>Chemical Plant and Petroleum Refinery Piping</td>
</tr>
<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-CG-0168</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>DNV Standard for Certification No. 2.22</td>
<td>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 8861</td>
<td>Shipbuilding - Engine-room ventilation in diesel-engined ships - Design requirements and basis of calculations</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>
</tbody>
</table>

4 Definitions

4.1 Verbal forms

Table 5 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 6 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</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 (SOLAS Reg. II-1/3.16) |
| 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. (SOLAS Reg. II-1/3.17) |
| machinery room              | room in which major items of equipment are installed  
                               | The term is used instead of Machinery Space on installations which are non-self propelled or fixed. Depending on the equipment involved requirements will be similar to those for either Machinery Space or Machinery Space of Category A. |
| 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  
                               | Marine piping systems include the following:  
                               | — ballast system  
                               | — bilge system  
                               | — drains system  
                               | — air/overflow systems  
                               | — sounding system  
                               | — cooling system  
                               | — lubricating oil system  
                               | — fuel oil system  
                               | — thermal oil system  
                               | — feed water and condensate systems  
                               | — steam system  
                               | — hydraulic system  
                               | — pneumatic system  
                               | — firewater system. |
| mobile offshore 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 collective term to cover any construction, buoyant or non-buoyant, designed and built for installation at a particular offshore location |
| redundancy                  | 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) |
5 Abbreviations and symbols

5.1 Abbreviations
Abbreviations used are given in Table 8.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full text</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>acrylonitrile butadiene styrene</td>
</tr>
<tr>
<td>AGMA</td>
<td>American Gear Manufacturers Association</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>ASA</td>
<td>American Standards Association</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>classification guideline</td>
</tr>
<tr>
<td>DIN</td>
<td>Deutsches Institut für Normung e.V.</td>
</tr>
<tr>
<td>EEMUA</td>
<td>Engineering Equipment and Materials Users Association</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>
<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>offshore standard</td>
</tr>
<tr>
<td>PT</td>
<td>dye-penetrant testing</td>
</tr>
<tr>
<td>PWHT</td>
<td>post weld heat treatment</td>
</tr>
<tr>
<td>RP</td>
<td>recommended practice</td>
</tr>
</tbody>
</table>
5.2 Symbols
Symbols used are given in Table 9.

Table 9 Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1$</td>
<td>nominal wall thickness</td>
</tr>
<tr>
<td>$T_0$</td>
<td>strength thickness in mm</td>
</tr>
<tr>
<td>$T$</td>
<td>minimum required wall thickness in mm</td>
</tr>
<tr>
<td>$C$</td>
<td>corrosion allowance in mm</td>
</tr>
<tr>
<td>$B$</td>
<td>bending allowance in mm</td>
</tr>
<tr>
<td>$\sigma_t$</td>
<td>permissible stress in N/mm²</td>
</tr>
<tr>
<td>$\sigma_b$</td>
<td>specified minimum tensile strength of the material in N/mm² at 20°C</td>
</tr>
<tr>
<td>$\sigma_{ft}$</td>
<td>specified minimum yield stress or 0.2% proof stress of the material in N/mm² at design material temperature</td>
</tr>
<tr>
<td>$p$</td>
<td>design pressure in bar</td>
</tr>
<tr>
<td>$D$</td>
<td>outer diameter of pipe in mm</td>
</tr>
<tr>
<td>$\sigma_{100000}$</td>
<td>average value for stress to rupture after 100 000 hours at design material temperature</td>
</tr>
<tr>
<td>$a$</td>
<td>percentage negative manufacturing tolerance</td>
</tr>
<tr>
<td>$e$</td>
<td>strength ratio</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.

Interpretation:

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.

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.
Interpretation:
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.

1.2 Prevention of inadvertent operations
The machinery and piping systems shall be so arranged that inadvertent operation leading to reduced safety of the unit or installation or personnel or environmental damage, cannot occur as a consequence of one single operational error.

Interpretation:
1) Open or closed position of valves should be easily visible.
2) If a valve’s function in the system is not evident, there should be adequate information on a name plate attached to the valve.
3) All connections to sea should be marked: SEA DIRECT.

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 in the control room from which the engines are normally controlled.

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.

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.

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.

1.7 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.

Interpretation:

For remotely controlled sea suction and discharge valves located in engine room each actuator should be fitted with a hand pump ready for use or an equivalent arrangement.

--------------- end of Interpretation  ---------------

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 class notation E0 see also DNV Rules for ships Pt.3 Ch.3 Sec.6.

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 When the valves are designed for actuator, the system transmitting the torque to the valve stem, or the valve stem itself shall be equipped with an interchangeable safety device such as breaking pins or equivalent.

1.7.7 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 of floating units and installations

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].

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.

1.9 Fittings on watertight bulkheads

1.9.1 Where a collision bulkhead is provided, any pipes penetrating collision bulkhead to be arranged in accordance with DNV Rules for 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.

Interpretation:

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 from above the waterline.

1.11 Refrigeration systems - ES
Fixed refrigeration plants (including air condition plants) with a total prime mover rated effect of 100 kW and above, shall comply with safety requirements as given in the DNV Rules for ships Pt.5 Ch.10. Refrigeration plants using Group 2 refrigerants (e.g. ammonia) shall comply with the safety requirements as given in Pt.5 Ch.10 irrespective of size.

Spaces containing refrigeration installations and not fitted with mechanical ventilations, shall be provided with an oxygen deficiency monitoring system. Alarm indication shall be located at the entrance to the space. Regarding routing of alarm to a manned control station, see also DNVGL-OS-D202, Ch.2 Sec.2 [1.4].

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:

— stabilized 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.

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

2.2.3 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 MODU code chapter 3. In no case need the equipment be designed to operate when inclined more than:

— 25° in any direction on a column-stabilized unit;
— 15° in any direction on a self-elevating unit; and
— 22.5° about the longitudinal axis and/or when inclined 10° about the transverse axis on a surface unit.
2.2.4 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 instrumentation are given in DNVGL-OS-D202 Ch.2 Sec.4.

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

2.2.5 Where the standard gives requirements for capacity or power of machinery, these shall be determined at the ambient reference conditions stated in Table 1.

Table 1 Ambient reference conditions for machinery

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total barometric pressure</td>
<td>1 bar</td>
</tr>
<tr>
<td>Ambient air temperature</td>
<td>45°C</td>
</tr>
<tr>
<td>Relative humidity of air</td>
<td>60%</td>
</tr>
<tr>
<td>Sea water temperature</td>
<td>32°C</td>
</tr>
</tbody>
</table>

2.2.6 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 (floating units)

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-OU-0101 Ch.1 Sec.3 [1] and DNVGL-OU-0102 Ch.1 Sec.3 [1], 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.

Interpretation:

For single engine propulsion plants all active components should be duplicated to satisfy [2.3.1] and [2.3.7].

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.

---------- end of Interpretation ----------
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 Ch.1 Sec.1 [4.2]). 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]).

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

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 offshore 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 are considered to 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 may 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.

    Interpretation:

    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 (DNVGL-OS-D101).

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 preventative maintenance throughout the intended lifetime of the unit or installation.

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

1.1.6 If a floating offshore installation other than MOU is intended to be built and disposed within the EU Member States (including EEA EFTA States) the piping design including components and materials must conform to the minimum safety requirements outlined in the "Pressure Equipment Directive 97/23/EC". Exclusions from the directive are listed in article no. 1 in the directive. Refer also Guideline 1/27 regarding MOU and FPSO. 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:

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

1.2 Categories of piping classification

1.2.1 Piping classification is applied on the basis of intended inventory, 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.

1.2.4 Class II and class III pipes shall normally not be used for design pressure or temperature conditions in excess of those shown in Table 1.

1.2.5 Class I pipes shall be used where either the maximum design pressure or temperature exceeds the applicable values of class II pipes.

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

1.2.7 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.
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. The following aspects should be considered when selecting materials:

— type of service
— compatibility with other materials in the system such as valve bodies and casings, for example in order to minimise bimetallic corrosion
— ability to resist general and localised corrosion or erosion caused by internal fluids and/or marine environment
— ability to resist selective corrosion, for example de-zincification of brass, de-aluminification of aluminium brass and graphitization of cast iron
— ductility
— need for special welding procedures
— need for special inspection, tests, or quality control.

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.

2.1.2 Materials to be used in the construction of piping systems shall be manufactured and tested in accordance with DNVGL-OS-B101.

2.1.3 Carbon steel materials are in general suitable for the majority of the piping systems.

2.1.4 Galvanised pipes are recommended as the minimum protection against corrosion for pipes in seawater systems, including those for bilge, air vent and ballast service.

2.1.5 Non-ferrous metallic materials may be accepted in piping system transporting flammable fluids and in bilge piping provided that fire endurance properties in accordance with a recognised code is documented.
2.2 Carbon and low alloy steel

2.2.1 Steel pipes for application as class I or class II, or for use where pressures exceed 40 bar, 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 normally 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 normally be used for class III piping, with the following exceptions:

---

— pipes and valves fitted on the unit or installation’s sides and bottom and on sea chests

---

— valves fitted on collision bulkhead

---

— valves under static head fitted on the external wall of fuel tanks

---

— bilge and ballast lines in tanks

---

— valves for fluids with temperatures in excess of 120°C.

2.4.4 Nodular graphite cast iron of the ferritic type, with a minimum elongation on $A_5$ of 12% ($L_0 = 5d$), 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 should not be used for media having a temperature exceeding 350°C, or less than 0°C.
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 may be used in systems and locations according to Table 3 provided the specified fire endurance requirements are fulfilled.

The permitted use is in conformance with IMO Resolution A.753(18) Guidelines for the Application of Plastic Pipes on Ships except for requirements for smoke generation and toxicity.

2.5.2 All pipes, except those fitted on open decks and within tanks, cofferdams, pipe tunnels and ducts shall have low surface flame spread characteristics not exceeding average values listed in IMO Resolution A.653(16). Surface flame spread characteristics may be determined using the test procedures given in ASTM D3806.

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 should generally 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 should 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.

2.5.4 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.

2.5.5 Plastic pipes may also be used for pneumatic and hydraulic control pipes within closed control cabinets, except in systems for remote control of systems for main functions.

This will include:

— steering gear
— fire extinguishing systems
— seawater valves (ballast and cooling)
— valves on fuel oil service tanks
— valves in bilge and fuel oil systems.

2.5.6 Plastic pipes used in piping systems subject to classification shall be of approved type and tested to an approved specification observing the requirements in [3.10].
### Table 3 Fire endurance requirements matrix

<table>
<thead>
<tr>
<th>Piping systems</th>
<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></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Other machinery spaces</td>
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<td></td>
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<tr>
<td>Cargo pump rooms</td>
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<tr>
<td>Other dry cargo holds</td>
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<td></td>
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<td></td>
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<tr>
<td>Cargo tanks</td>
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<td></td>
<td></td>
<td></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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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Coffer dams, void spaces, pipe</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>tunnel and ducts</td>
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</tr>
<tr>
<td>Accommodation service</td>
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<td></td>
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<tr>
<td>and control spaces</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open decks</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th></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>1 Crude or oil product lines</td>
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<td>NA</td>
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<td>NA</td>
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<td>9</td>
<td>NA</td>
<td>L1</td>
</tr>
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<td>NA</td>
<td>0</td>
<td>9</td>
<td>NA</td>
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#### INERT GAS

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<th>G</th>
<th>H</th>
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<th>J</th>
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<tbody>
<tr>
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<td>NA</td>
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<tr>
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<td>NA</td>
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<td>1</td>
<td>NA</td>
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<td>6 Main line</td>
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<td>L1</td>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
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<td>NA</td>
<td>L1</td>
</tr>
<tr>
<td>7 Distribution lines</td>
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<td>NA</td>
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<td>NA</td>
<td>L1</td>
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</table>

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

<table>
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<tr>
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<th>D</th>
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<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Crude or oil product lines</td>
<td>X</td>
<td>X</td>
<td>L1</td>
<td>X</td>
<td>NA</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>NA</td>
</tr>
<tr>
<td>9 Fuel oil</td>
<td>X</td>
<td>X</td>
<td>L1</td>
<td>X</td>
<td>NA</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>L1</td>
</tr>
<tr>
<td>10 Lubricating oil</td>
<td>X</td>
<td>X</td>
<td>L1</td>
<td>X</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0</td>
<td>L1</td>
<td>L1</td>
</tr>
<tr>
<td>11 Hydraulic oil</td>
<td>X</td>
<td>X</td>
<td>L1</td>
<td>X</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>L1</td>
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</table>

#### SEAWATER 1)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Bilge main and branches</td>
<td>L1</td>
<td>L1</td>
<td>L1</td>
<td>X</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>L1</td>
</tr>
<tr>
<td>13 Fire main and water spray</td>
<td>L1</td>
<td>L1</td>
<td>L1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>14 Foam system</td>
<td>L1</td>
<td>L1</td>
<td>L1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0</td>
<td>L1</td>
<td>L1</td>
</tr>
<tr>
<td>15 Sprinkler system</td>
<td>L1</td>
<td>L1</td>
<td>L3</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0</td>
<td>L3</td>
<td>L3</td>
<td></td>
</tr>
<tr>
<td>16 Ballast</td>
<td>L3</td>
<td>L3</td>
<td>L3</td>
<td>X</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>L2</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>17 Cooling water, essential services</td>
<td>L3</td>
<td>L3</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0</td>
<td>NA</td>
<td>L2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 Tank cleaning services, fixed machines</td>
<td>NA</td>
<td>NA</td>
<td>L3</td>
<td>NA</td>
<td>0</td>
<td>NA</td>
<td>0</td>
<td>NA</td>
<td>L3</td>
<td></td>
</tr>
<tr>
<td>19 Non-essential systems</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

#### FRESHWATER

<table>
<thead>
<tr>
<th></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>20 Cooling water, essential services</td>
<td>L3</td>
<td>L3</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>L3</td>
<td>L3</td>
</tr>
<tr>
<td>21 Condensate return</td>
<td>L3</td>
<td>L3</td>
<td>L3</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<td>0</td>
</tr>
<tr>
<td>22 Non-essential systems</td>
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<td>0</td>
<td>0</td>
<td>NA</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

#### SANITARY OR DRAINS OR SCUPPERS

<table>
<thead>
<tr>
<th></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>23 Deck drains (internal)</td>
<td>L1</td>
<td>L1</td>
<td>NA</td>
<td>0</td>
<td>NA</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>24 Sanitary drains (internal)</td>
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<td>NA</td>
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<tr>
<td>25 Scuppers and discharges (overboard)</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
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</table>

#### SOUNDING OR AIR

<table>
<thead>
<tr>
<th></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>26 Water tanks/dry spaces</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>27 Oil tanks (flash point &gt; 60°C)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>X</td>
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</tr>
</tbody>
</table>

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1) Numbers in the table represent the fire endurance requirements.
Table 3 Fire endurance requirements matrix (Continued)

<table>
<thead>
<tr>
<th>Piping systems</th>
<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></td>
<td>Machinery spaces of category A</td>
<td>L1 5)</td>
<td>L1 5)</td>
<td>L1 5)</td>
<td>L1 5)</td>
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<td>L1 5)</td>
<td>L1 5)</td>
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<tr>
<td></td>
<td>Other machinery spaces</td>
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<td>L1 5)</td>
<td>L1 5)</td>
</tr>
<tr>
<td></td>
<td>Cargo pump rooms</td>
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<td>Cargo tanks</td>
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<tr>
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<td>Ballast water tanks</td>
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<td>Coffers, voids spaces, pipe tunnel and ducts</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Accommodation service and control spaces</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Open decks</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Abbreviations used**
- L1 Fire endurance test in dry conditions, 60 minutes Appendix 1 of IMO Res. A.753(18)
- L2 Fire endurance test in dry conditions, 30 minutes Appendix 1 of IMO Res. A.753(18)
- L3 Fire endurance test in wet conditions, 30 minutes Appendix 2 of IMO Res. A.753(18)
- 0 No fire endurance test required
- NA Not applicable
- X Metallic materials having a melting point greater than 925°C.

**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(f) of regulation 13F of Annex I of MARPOL 73/78 is required, «NA» is to replace «0».

**Location definitions used in Table 3**
- A - Machinery spaces of category A
- B - Other machinery spaces and pump rooms
- C - Cargo pump rooms
- D - Other dry cargo holds
- E - Cargo tanks
- F - Fuel oil tanks
- G - Ballast water tanks
- H - Coffers, voids spaces, pipe tunnel and ducts
- I - Accommodation, service and control spaces
- J - Open decks

- 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.
- Spaces containing cargo pumps and entrances and trunks to such spaces.
- All spaces other than ro-ro cargo holds used for non-liquid cargo and trunks to such spaces.
- All spaces used for liquid cargo and trunks to such spaces.
- All spaces used for fuel oil (excluding cargo tanks) and trunks to such spaces.
- All spaces used for ballast water and trunks to such spaces.
- Coffers and voids are those empty spaces between two bulkheads separating two adjacent compartments.
- Accommodation spaces, service spaces and control stations as defined in SOLAS 1974, as amended, regulation II-2/3.10, 3.12, 3.22.
- Open deck spaces as defined in SOLAS 1974, as amended, regulation II-2/26.2.2(5).
2.5.7 Use of GRE/GRP piping in firewater systems will be subject to special consideration with respect to use of standard fire testing methods. The following parameters will 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:
Reference is made to USCG PFM 1-98: Policy File Memorandum on the Fire Performance Requirements for Plastic Pipe per IMO Resolution A.753(18).

---e-n-d---of---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, 703 and 704.

2.7.2 Major pressure retaining bolts and nuts with specified minimum yield stress above 490 N/mm² shall be made of alloy steel, i.e. (% Cr+% Mo+% Ni) \(\geq 0.50\), 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>
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 should be considered. Piping under internal pressure shall also meet the requirements of [3.4].
3.3.2 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.

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

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

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

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

### Table 6 Minimum nominal wall thickness for pipes of copper and copper alloys

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

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].

3.4.2 Definition of symbols:

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

3.4.3 The design pressure, \( p \), to be used in the formula in [3.4.10], is defined as the maximum allowable working pressure, and shall not be less than the highest set pressure of the safety valve or relief device.
3.4.4 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.

f) 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 shall not be less than A.S.A. pipe schedule 40.

<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) 8) 9)</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) 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.2 &lt; ( D \leq 12 )</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.5 &lt; ( D \leq 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 \leq 25 )</td>
<td>2</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.9 &lt; ( D \leq 33.7 )</td>
<td>2</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38 &lt; ( D \leq 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 \leq 63.5 )</td>
<td>2.3</td>
<td>4.5</td>
<td>4.0</td>
<td>6.3</td>
</tr>
<tr>
<td>70</td>
<td>2.6</td>
<td>4.5</td>
<td>4.0</td>
<td>6.3</td>
</tr>
<tr>
<td>76.1 &lt; ( D \leq 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 \leq 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 \leq 127 )</td>
<td>3.2</td>
<td>4.5</td>
<td>4.5</td>
<td>8.0</td>
</tr>
<tr>
<td>133 &lt; ( D \leq 139.7 )</td>
<td>3.6</td>
<td>4.5</td>
<td>4.5</td>
<td>8.0</td>
</tr>
<tr>
<td>152.4 &lt; ( D \leq 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>5.0</td>
<td>5.0</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>
<tr>
<td>219.1</td>
<td>4.5</td>
<td>5.9</td>
<td>5.9</td>
<td>8.8</td>
</tr>
<tr>
<td>244.5 &lt; ( D \leq 273 )</td>
<td>5</td>
<td>6.3</td>
<td>6.3</td>
<td>8.8</td>
</tr>
<tr>
<td>298.5 &lt; ( D \leq 368 )</td>
<td>5.6</td>
<td>6.3</td>
<td>6.3</td>
<td>8.8</td>
</tr>
<tr>
<td>406.4 &lt; ( D \leq 457 )</td>
<td>6.3</td>
<td>6.3</td>
<td>6.3</td>
<td>8.8</td>
</tr>
</tbody>
</table>

1) For pipes efficiently protected against corrosion, the thickness may be reduced by 20% of the required thickness, but not more than 1 mm.

2) For sounding pipes, except those for storage tanks with cargo having a flash point less than 60°C, the minimum wall thickness is intended to apply to the part outside the tank.

3) For threaded pipes, where allowed, the minimum wall thickness shall be measured at the bottom of the thread.

4) The minimum wall thickness for bilge lines and ballast lines through deep tanks and for cargo lines is subject to special consideration.

5) For larger diameters the minimum wall thickness is subject to special consideration.

6) The wall thickness of hydraulic pipes in oil tanks in systems for remote control of oil valves shall be no less than 4 mm.

7) For inlets and sanitary discharges, see DNVGL-OS-C301.

8) For stainless steel pipes, the minimum wall thickness will be specially considered, but it is in general not to be less than given in Table 8.

9) For air pipes on exposed decks, see DNVGL-OS-C301.
3.4.5 The design temperature to be considered for determining the permissible stresses shall be the maximum temperature of the medium inside the pipe.

3.4.6 The design temperature requirements in [3.4.5] 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 normally 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°C or 5°C above the normal working temperature will be of short duration.

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

\[ t = t_0 + c \]

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

\[ t + b \]

3.4.9 These terms are further addressed in [3.4.10] to [3.4.17].

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

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

3.4.11 The formula in [3.4.10] is valid for pipes having a ratio of wall thickness to outside diameter of 0.17 or less. Where this ratio exceeds 0.17, special consideration shall be given to the calculation of wall thickness.

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

\[
\begin{align*}
\sigma_t & \geq \frac{\sigma_{u2}}{2.7} \quad \text{(for austenitic)} \\
& \geq \frac{\sigma_{u2}}{1.6} \quad \text{or} \\
& \geq \frac{\sigma_{u2}}{1.8} \quad \text{and} \quad \sigma_{u2000} \quad \text{for other materials}
\end{align*}
\]
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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>up to 50</td>
</tr>
<tr>
<td>Copper, annealed</td>
<td>220</td>
<td>42</td>
</tr>
<tr>
<td>Copper, ‹‹semi-hard››</td>
<td>250</td>
<td>42</td>
</tr>
<tr>
<td>Aluminium-Brass 2) annealed</td>
<td>330</td>
<td>80</td>
</tr>
<tr>
<td>Copper-Nickel 90/10 annealed</td>
<td>290</td>
<td>70</td>
</tr>
<tr>
<td>Copper-Nickel 70/30 annealed</td>
<td>360</td>
<td>83</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

3.4.13 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.

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

3.4.15 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.

3.4.16 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:

\[ b = \frac{1}{2.5} \frac{D}{R} t_0 \]

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

3.4.17 Corrosion allowance c

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.

3.4.18 The value of t does not account for any negative manufacturing tolerance, therefore the nominal wall thickness, \( t_1 \), shall not be less than:

\[
t_1 = \frac{t}{1 - \frac{d}{100}}
\]

3.4.19 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 [3.4.20]. However, the validity of [3.4.20] is limited by a maximum ratio for branch lines wall thickness/main line wall thickness of 2.

3.4.20 The minimum pipe wall thickness of main pipes at a branch connection shall not be less than:

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

3.4.21 In the above equation:

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

\[e = \frac{t_1 \sin \gamma}{1.25 + \frac{d_{\text{max}} - d_{\text{min}}}{2d_{\text{min}}}}
\]

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

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

\[\gamma = \text{angle between centre lines of main pipe and branch } \gamma \text{ is not to be less than } 45^\circ\]
Figure 1  Basic strength ratio

Figure 2  Details of main pipe and branch pipe
3.5 Thermal expansion stresses

For piping systems for steam at temperatures above 400°C, an analysis of thermal stresses is normally to be performed. 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.

3.7 Stress calculation

3.7.1 When a thermal stress analysis of a piping system between two or more anchor points is carried out, the system shall be treated as a whole. The significance of all parts of the line, of restraints such as solid hangers, sway braces and guides and of intermediate restraints built in for the purpose of reducing loads on equipment or small branch lines, shall be duly considered. The stress analysis shall be carried out on the assumption that the piping system expands from 20°C to the highest operating temperature. The modulus of elasticity to be used for the pipe material, is the value of same at 20°C.

3.7.2 In carrying out a thermal stress analysis, stress concentration factors found to exist in components other than straight pipes, shall be taken into account. In cases where it is known that such components possess extra flexibility, this may be incorporated in the stress calculations. Stress concentration factors and flexibility factors given in Table 11 will be accepted for use in the calculations when other substantiated factors may be lacking.

3.7.3 The thermal expansion resultant stress $\sigma_r$ is defined as:

$$\sigma_r = \sqrt{\sigma_b^2 + 4 \tau^2} \quad (N/mm^2)$$

$$\sigma_b = \frac{\sqrt{(i_1 M_1)^2 + (i_0 M_0)^2}}{Z}$$

= total bending stress (N/mm$^2$)

$$\tau = \frac{M_T}{2Z}$$

= torsional stress in (N/mm$^2$)

$M_T$ = torsional moment (Nm)

$M_1$ = bending moment in plane of member (Nm)

$M_0$ = bending moment transverse to plane of member (Nm)

$i_1$ = stress concentration factor for in-plane bending moments

$i_0$ = stress concentration factor for out-of-plane bending moments

$Z$ = section modulus in bending of member (mm$^3$).

When the member cross-section in non-uniform, the section modulus of the matching pipe shall be used. For branched systems, where the branch diameter is less than the header diameter, the branch section modulus may be taken as the smaller value of:

$$\pi r_b^2 t_h$$ and $$\pi r_b^2 i_{ib} t_b$$

$r_b$ = mean cross-sectional radius of branch (mm)

$t_h$ = thickness of pipe which matches header (mm)
\[ t_b = \text{thickness of pipe which matches branch (mm)} \]

\[ i_{ib} = \text{in-plane stress concentration factor for branch.} \]

**3.7.4** The resultant stress \( \sigma_r \) is at no point of the piping system to exceed the corresponding stress range \( \sigma_{\text{int}} \):

\[ \sigma_{\text{int}} = 0.75 \sigma_{tk} + 0.25 \sigma_{tv} \]

\( \sigma_{tk} \) = permissible pipe wall stress at 100°C or lower (N/mm\(^2\))

\( \sigma_{tv} \) = permissible pipe wall stress at maximum working temperature of system (N/mm\(^2\)).

For low temperature piping \( \sigma_{\text{int}} \) shall be determined upon special consideration.

**3.7.5** The sum of axial bending stress in the pipe wall due to static loading (pipe weight) and axial tensile stress due to internal pressure, is at no point in the system to exceed the permissible stress \( \sigma_{tv} \).

### Table 11 Stress concentration factors and flexibility factors for metallic pipe-line elements

<table>
<thead>
<tr>
<th>Type of element</th>
<th>Sketch</th>
<th>Flexibility parameter ( \gamma )</th>
<th>Flexibility factor ( k )</th>
<th>In-plane stress concentration factor ( i_i ) (^{1)} )</th>
<th>Out-of-plane stress concentration factor ( i_0 ) (^{1)} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight buttwelded pipe</td>
<td><img src="image1" alt="Sketch" /></td>
<td>( \frac{tR}{r_m^2} )</td>
<td>( \frac{1.65}{\gamma} \left[ 1 + 6 \frac{p}{E_K} \frac{r_m}{t} \left( \frac{R}{r_m} \right)^{1/3} \right] )</td>
<td>( \frac{0.9}{\gamma^{2/3}} )</td>
<td>( \frac{0.75}{\gamma^{2/3}} )</td>
</tr>
<tr>
<td>Curved pipe</td>
<td><img src="image2" alt="Sketch" /></td>
<td>( \frac{4.4}{r_m} )</td>
<td>1.0</td>
<td>( \frac{3}{4} i_0 + 0.25 )</td>
<td>( \frac{0.9}{\gamma^{2/3}} )</td>
</tr>
<tr>
<td>Welding tee</td>
<td><img src="image3" alt="Sketch" /></td>
<td>( \frac{t_h}{r_m} )</td>
<td>1.0</td>
<td>( \frac{3}{4} i_0 + 0.25 )</td>
<td>( \frac{0.9}{\gamma^{2/3}} )</td>
</tr>
<tr>
<td>Fabricated tee</td>
<td><img src="image4" alt="Sketch" /></td>
<td>( \frac{t_H}{r_m} )</td>
<td>( \frac{0.9}{\gamma^{2/3}} )</td>
<td>( \frac{0.9}{\gamma^{2/3}} )</td>
<td>( \frac{0.9}{\gamma^{2/3}} )</td>
</tr>
</tbody>
</table>

\(^{1)} i_0 \) and \( i_i \) shall be taken less than 1.0.

---


Marine and machinery systems and equipment

DNV GL AS
Guidance note:
If the piping system is fitted with pre-stress (cold spring), allowance for this is given in evaluating the pipe reaction forces on connected machinery. The following formulae for estimating pipe reaction forces may be applied whenever an effective method of obtaining the designed pre-stress is specified and used, and may be used for calculating the hot and cold reaction forces, respectively:

\[ R_V = \left( 1 - \frac{2}{3} C \right) \frac{E_V}{E_K} R \]

\[ R_K = C_R \quad \text{or} \quad R_K = \left( 1 - \frac{\sigma_{tv}}{\sigma_r} \frac{E_K}{E_V} \right) R \]

whichever is the greater.

- \( R \): reaction force at 20°C with no pre-stress (N)
- \( C \): amount of pre-stress; with no pre-stress \( C = 0.0 \); with 100% pre-stress \( C = 1.0 \)
- \( E_V \): modulus of elasticity for pipe material in hot condition (N/mm\(^2\))
- \( E_K \): modulus of elasticity for pipe material at 20°C (N/mm\(^2\)).

The quantity:

\[ \frac{\sigma_{tv}}{\sigma_r} \frac{E_K}{E_V} \]

is in all cases to be less than 1.0.

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

3.8 Wall thickness of heavy high pressure pipes

3.8.1 A combined stress calculation according to von Mises’ theory may be applied for high pressure piping where the wall thickness to outer diameter ratio is outside that given in [3.4.11]. The equivalent combined stress at any point of the piping wall shall not exceed 60% of the minimum specified yield strength of the material.

3.8.2 The equivalent combined stress as defined by von Mises is:

\[ \sigma_e = 0.707 \sqrt{\left( \sigma_\theta - \sigma_1 \right)^2 + \left( \sigma_1 - \sigma_r \right)^2 + \left( \sigma_r - \sigma_\theta \right)^2} \]

- \( \sigma_e \): equivalent (von Mises) combined stress
- \( \sigma_\theta \): circumferential or hoop stress
- \( \sigma_1 \): longitudinal or axial stress
- \( \sigma_r \): radial stress

Guidance note:
The calculations \( \sigma_\theta, \sigma_1 \ and \ \sigma_r \) may be based on Lame’s equations for cylinders.

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

3.9 Piping flexibility and support

3.9.1 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:

- Carbon steel pipes: 1.16 mm per °C per 100 m
- Austenitic steel pipes: 1.35 mm per °C per 100 m
- Copper alloy: 1.42 mm per °C per 100 m
3.9.2 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.

3.9.3 Flexibility analysis according to DNV-RP-D101 Structural Analysis of Piping Systems may be provided as documentation of adequate piping flexibility and support.

3.10 Plastic pipes

3.10.1 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 h) test failure pressure by a safety factor 2.5

whichever is the lesser.

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

3.10.3 The nominal external pressure for a pipe 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.

3.10.4 High temperature limits and pressure relative to nominal pressures should be according to the recognised standard subject to [3.10.5].

3.10.5 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.

3.10.6 Temperature limits and pressure reductions shall be as shown in Table 12 and Table 13 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.

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

Table 12 Thermoplastic pipes. Permissible pressures and temperature limits

<table>
<thead>
<tr>
<th>Material</th>
<th>Nominal pressure 1) (bar)</th>
<th>Permissible working pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \leq 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.
3.10.8 Thermoplastic pipes for installation in external areas shall either be specifically approved for external use, or shall be protected against ultraviolet radiation.

3.10.9 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.

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

3.10.11 Where design loads incorporate a significant cyclic or fluctuating component, fatigue effects shall be considered in material selection and installation design.

3.10.12 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.

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

4.3.2 The pump characteristic (head-capacity curve) shall be determined for all centrifugal pumps having capacities less than 1 000 m³/h.

4.3.3 For centrifugal pumps having capacities equal to or greater than 1 000 m³/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 Bolted bonnets having bonnet secured to body by less than four bolts and/or having secured bonnet by U-bolts will 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 are normally to 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 are to 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].

5.1.13 Valve bodies of nominal size DN 50 and larger shall be self draining or be equipped with drain plug.
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 and 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 Short lengths of flexible hoses may be used when necessary to permit relative movements between machinery and fixed piping systems. Hoses with couplings shall be type approved.

6.1.2 Fire tests are required for hoses intended for systems conveying flammable liquids or for use in sea water cooling systems.

6.1.3 In fresh cooling water lines for diesel engines and compressors, the requirements in [6.1.1] and [6.1.2] need not apply where each engine is provided with an independent cooling system.

6.1.4 Rubber hoses with internal textile reinforcement fitted by means of hose clamps may be adequate in cases where the hose is a short, reasonably straight length fitted between two metallic pipes with double hose clamps on each side.

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

6.1.6 All hoses shall be hydrostatically tested at a hydrostatic pressure of 1.5 times the 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 not be used in bilge and ballast 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 will normally be 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 14 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)
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. The approval shall be based on DNV Type Approval Programme 5-792.20. Examples of mechanical joints are shown in Table 15.

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 16. Dependence upon the Class of piping, pipe dimensions, working pressure and temperature is indicated in Table 17.

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 recognized 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.

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---of---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.

![Diagram of pipe flanges]

Figure 4 Types of pipe flanges

Table 14 Type of flange connections

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

1) Type B or outer diameter < 150 mm only.
### Table 15 Examples of mechanical joints

<table>
<thead>
<tr>
<th>Pipe Unions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Welded and Brazed Types</strong></td>
</tr>
<tr>
<td><img src="image1" alt="" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compression Coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Swage Type</strong></td>
</tr>
<tr>
<td><img src="image2" alt="" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Press Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bite Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4" alt="" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flared Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5" alt="" /></td>
</tr>
</tbody>
</table>
### Table 15  Examples of mechanical joints (Continued)

<table>
<thead>
<tr>
<th>Grip Type</th>
<th>Machined Grooved Type</th>
<th>Slip Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
</tr>
</tbody>
</table>

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 16 Application of mechanical joints

<table>
<thead>
<tr>
<th>Systems</th>
<th>Kind of connections</th>
<th>Pipe Unions</th>
<th>Compression Couplings</th>
<th>Slip-on Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flammable fluids (flash point ≤ 60°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Cargo oil lines</td>
<td>+</td>
<td>+</td>
<td>+5)</td>
<td></td>
</tr>
<tr>
<td>2 Crude oil washing lines</td>
<td>+</td>
<td>+</td>
<td>+5)</td>
<td></td>
</tr>
<tr>
<td>3 Vent lines</td>
<td>+</td>
<td>+</td>
<td>+3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inert gas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Water seal effluent lines</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>5 Scrubber effluent lines</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>6 Main lines</td>
<td>+</td>
<td>+</td>
<td>+2)3)</td>
<td></td>
</tr>
<tr>
<td>7 Distributions lines</td>
<td>+</td>
<td>+</td>
<td>+5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flammable fluids (flash point &gt; 60°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Cargo oil lines</td>
<td>+</td>
<td>+</td>
<td>+5)</td>
<td></td>
</tr>
<tr>
<td>9 Fuel oil lines</td>
<td>+</td>
<td>+</td>
<td>+3)2)</td>
<td></td>
</tr>
<tr>
<td>10 Lubricating oil lines</td>
<td>+</td>
<td>+</td>
<td>+2)3)</td>
<td></td>
</tr>
<tr>
<td>11 Hydraulic oil</td>
<td>+</td>
<td>+</td>
<td>+3)3)</td>
<td></td>
</tr>
<tr>
<td>12 Thermal oil</td>
<td>+</td>
<td>+</td>
<td>+2)3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sea water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Bilge lines</td>
<td>+</td>
<td>+</td>
<td>+1)</td>
<td></td>
</tr>
<tr>
<td>14 Fire main and water spray</td>
<td>+</td>
<td>+</td>
<td>+3)3)</td>
<td></td>
</tr>
<tr>
<td>15 Foam system</td>
<td>+</td>
<td>+</td>
<td>+3)3)</td>
<td></td>
</tr>
<tr>
<td>16 Sprinkler system</td>
<td>+</td>
<td>+</td>
<td>+3)3)</td>
<td></td>
</tr>
<tr>
<td>17 Ballast system</td>
<td>+</td>
<td>+</td>
<td>+1)</td>
<td></td>
</tr>
<tr>
<td>18 Cooling water system</td>
<td>+</td>
<td>+</td>
<td>+1)</td>
<td></td>
</tr>
<tr>
<td>19 Tank cleaning services</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>20 Non-essential systems</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fresh water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 Cooling water system</td>
<td>+</td>
<td>+</td>
<td>+1)</td>
<td></td>
</tr>
<tr>
<td>22 Condensate return</td>
<td>+</td>
<td>+</td>
<td>+1)</td>
<td></td>
</tr>
<tr>
<td>23 Non-essential system</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sanitary/drains/scuppers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 Deck drains (internal)</td>
<td>+</td>
<td>+</td>
<td>+4)</td>
<td></td>
</tr>
<tr>
<td>25 Sanitary drains</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>26 Scuppers and discharge (overboard)</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sounding/vent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27 Water tanks/Dry spaces</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>28 Oil tanks (f.p. &gt; 60°C)</td>
<td>+</td>
<td>+</td>
<td>+2)3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Miscellaneous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 Starting/Control air</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>30 Service air (non-essential)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>
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 may be 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 may be used for class III.

8.1.3 Joint designs and socket dimensions in accordance with a recognised 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.

---

### Table 16 Application of mechanical joints (Continued)

<table>
<thead>
<tr>
<th>Systems</th>
<th>Pipe Unions</th>
<th>Compression Couplings</th>
<th>Slip-on Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>31 Brine</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>32 CO₂ system</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>33 Steam</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Abbreviations:**

+ Application is allowed
- Application is not allowed

**Footnotes:**

1) Inside machinery spaces of category A - only approved fire resistant types
2) Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.
3) Approved fire resistant types
4) Above free board deck only
5) In pump rooms and open decks - only approved fire resistant types
6) If Compression Couplings include any components which readily deteriorate in case of fire, they shall be of approved fire resistant type as required for Slip-on joints
7) Approved slip type joints as shown in Table 15, provided that they are restrained on the pipes, may be used for pipes on deck with a design pressure of 10 bar or less.

---

### Table 17 Application of mechanical joints depending upon the class of piping

<table>
<thead>
<tr>
<th>Types of joints</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pipe Unions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welded and brazed type</td>
<td>+ (OD ≤ 60.3 mm)</td>
<td>+ (OD ≤ 60.3 mm)</td>
<td>+</td>
</tr>
<tr>
<td><strong>Compression Couplings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swage type</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Bite type</td>
<td>+ (OD ≤ 60.3 mm)</td>
<td>+ (OD ≤ 60.3 mm)</td>
<td>+</td>
</tr>
<tr>
<td>Flared type</td>
<td>+ (OD ≤ 60.3 mm)</td>
<td>+ (OD ≤ 60.3 mm)</td>
<td>+</td>
</tr>
<tr>
<td>Press type</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><strong>Slip-on joints</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine grooved type</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Grip type</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Slip type</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Abbreviations:**

+ Application is allowed
- Application is not allowed
SECTION 3 PLATFORM PIPING SYSTEMS

1 General

1.1 Scope

1.1.1 The requirements of this standard have been specifically aimed at mobile offshore 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 DNV Rules for ships Pt.4 Ch.6.

1.1.3 The requirements in this section are applicable to piping systems for tanks and dry compartments.

1.2 Location of piping and control systems

1.2.1 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.

1.2.2 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.

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.

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.

2.1.3 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.

2.1.4 The systems shall be so designed that one single failure or maloperation of equipment will not lead to uncontrolled liquid movement, e.g. a series of tanks or a single tank shall not be filled unintentionally if that may result in a critical condition of the unit or installation.

2.1.5 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.

2.3.3 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.

2.3.4 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.

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

2.3.6 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.

2.3.7 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.

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

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

2.4 Drainage of dry compartments above main deck
Dry watertight compartments below damage water line may be drained by one of the following methods:
— by permanently installed bilge system
— by draining directly to sea through easily accessible closable non-return valves
— by 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.

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:

$$d = 2.15 \sqrt{A} + 25 \ (mm)$$

where A is wetted surface in m² 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 is not to be less than that of the suction side of the pump, but need not exceed 400 mm.

2.6.4 Bilge suction pipes are, as far as practicable, not to 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, is not to 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>
<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>
</tr>
<tr>
<td>55</td>
<td>18</td>
<td>95</td>
<td>52</td>
</tr>
<tr>
<td>60</td>
<td>21</td>
<td>100</td>
<td>58</td>
</tr>
<tr>
<td>65</td>
<td>25</td>
<td>105</td>
<td>64</td>
</tr>
<tr>
<td>70</td>
<td>29</td>
<td>110</td>
<td>70</td>
</tr>
<tr>
<td>75</td>
<td>33</td>
<td>115</td>
<td>76</td>
</tr>
<tr>
<td>80</td>
<td>37</td>
<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 = 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.

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 DNV Rules for ships Pt.6 Ch.18 Sec.4.

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.

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.

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.

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.

Guidance note:
It is advised to arrange separate fusing in each valve control circuit.

3.2.7 Commands given from the remote control panel shall be clearly indicated.

3.3 Ballast system

3.3.1 The ballast system shall be capable of operating after the damage condition as specified in IMO MODU Code (3.5.10) 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. Counterflooding may be considered as an operational procedure.

3.3.2 The sea water inlets to the ballast system are normally to 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 should 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.

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 \( h_{op2} \) 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.

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 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 DNV Rules for ships Pt.6 Ch.18 Sec.4.

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 are to have their own separate pumping system.
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.

5 Ballast and bilge systems for ship-shaped units and installations
Requirements for ship-shaped units are given in DNV Rules for ships Pt.4 Ch.6.

6 Air, overflow and sounding pipes

6.1 Arrangement of air pipes
6.1.1 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.
6.1.2 Air pipes are not to 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.
6.1.3 Air pipes from tanks which can be filled from the sea and from sea chests shall be carried up to above the freeboard deck.
6.1.4 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 are to 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.

6.1.5 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.

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

6.1.7 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.

6.1.8 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.

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

6.1.10 All air pipes shall be clearly marked at the upper end.

6.1.11 Air pipes shall be self draining under normal conditions of trim.

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

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

6.2 Air pipes, sectional area

6.2.1 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.

Alternatively, arrangements for prevention of over pumping of tanks may be accepted. See also [3.3.5].

The sectional area of the air pipes is 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 will be 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].

6.2.2 For tanks which can be filled by pumps not installed in the unit or installation, the maximum allowable pump capacity shall be stated on signboards at the filling pipe connection.

6.2.3 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.

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

6.2.5 Pipe tunnels shall be fitted with an air pipe with an internal diameter not less than 75 mm.
6.2.6 Rooms fitted with emergency bilge suction according to [2.3.8] shall be fitted with air pipe and vent heads of sufficient size to ensure efficient ventilation during an emergency bilge operation. The vents shall be designed to accommodate the maximum pumping rate of emergency bilging.

6.3 Overflow pipes, arrangement

6.3.1 Fuel oil and lubricating oil tanks which can be pumped up and which have openings into the room or void in which they are located shall be fitted with overflow pipes discharging to an overflow tank or bunker oil tank with surplus capacity. The tank openings shall be situated above the highest point of the overflow piping. Typical openings are for the wire for a float sounding system.

6.3.2 The overflow tanks shall have sufficient capacity.

Interpretation:
1) Sufficient capacity is a capacity large enough to take an overflow of ten minutes at the normal rate of filling.
2) As an alternative a storage tank may be used for overflow purposes, provided a signboard is fitted ensuring sufficient volume for overflow is ensured.

-------------------- end of Interpretation -------------------

6.3.3 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.

6.3.4 Where tanks for the carriage of oil or water ballast are connected to an overflow system, the pipe arrangement shall be such that water ballast cannot overflow into tanks containing oil.

6.3.5 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.

Interpretation:
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.

-------------------- end of Interpretation -------------------

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

6.4 Overflow pipes, sectional area
The sectional area of overflow pipes shall be dimensioned in accordance with the requirement in [6.2.1].

6.5 Sounding arrangements

6.5.1 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.

6.5.2 For column-stabilised units or installations the indications in [6.5.1] shall be provided in the centralised control room.

6.5.3 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.

6.5.4 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.
6.5.5 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 [6.5.6]).

Sounding pipes to tanks containing liquids which have a flash point below 60°C (closed cup), are always to 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.

6.5.6 Short sounding pipes may be fitted to double bottom oil tanks, in shaft tunnels and machinery spaces and to tanks for lubricating oil and hydraulic oil which can be pumped up, provided the pipes are readily accessible, and the following conditions 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.

6.5.7 If oil gauges of glass are used for ascertaining the level of oil in storage, settling or daily service tanks for fuel and lubricating oil, the glasses shall be of heat-resisting material, suitably protected and fitted with self-closing cocks at the lower ends and also at the top ends, if the connections to the tanks are below the maximum oil level. The gauges shall be adequately supported.

6.5.8 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.

6.5.9 Remote sounding system of approved type may replace ordinary sounding pipes or gauges as follows:

a) 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.

b) For tanks which are 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.

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

6.5.11 Large, watertight deck areas above the freeboard deck, containing piping systems that can supply large amounts of water in case of pipe rupture, shall have leak detectors and remotely controlled drainage valves of adequate capacity.

6.6 Sounding pipes, sectional area

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

6.6.2 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)
7 Storage and transfer systems for liquids with flashpoint below 60°C (e.g. helicopter fuel)

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

7.2 Arrangement

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

7.2.2 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.

7.2.3 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.

7.2.4 The air pipes to the tanks shall be provided with pressure/vacuum relief valves. The valves shall be of sufficient capacity to relieve the overpressure-vacuum which occurs during filling or emptying at maximum rate.

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

7.2.6 The fuel storage area shall be arranged with means by which spillage can be collected and drained to a safe location.

7.2.7 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.

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

7.2.9 Corrosion resistant material, lining or coating may be required in the tanks and piping systems in order to ensure proper fuel cleanliness.

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

7.2.11 Fuel transfer system for helicopter refuelling shall be earthed.
SECTION 4  MACHINERY PIPING SYSTEM

1  General

1.1  Scope

1.1.1  The requirements of this standard have been specifically aimed at mobile offshore 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 DNV Rules for ships Pt.4 Ch.1 and Ch.6.

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  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.

2.1.3  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.

2.1.4  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 DNV Rules for ships Pt.5 Ch.1.
2.2.5 Regarding sea inlets see Sec.1 [1.8].

3 Lubricating oil system

3.1 General
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.

3.2 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, a bypass shall be arranged.
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 shut-off arrangement for lubricating oil tanks
Valves on lubricating oil tanks situated above the double bottom and which are open during normal service shall be arranged for remote shut-off if such valves are located below top of the tank or overflow outlet. Based on case by case consideration, this requirement may be waived for small tanks, with volume less than 0.5 m³, and tanks for which an unintended closing of the valves may result in loss of main functions specified in [1].

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 shall 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 Fuel oil daily service tanks for heavy fuel oil shall be constructed with smooth bottoms with slope towards drainage outlet required by [4.10.1]. 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 are not to be routed through fresh water tanks.

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

4.4 Arrangement of valves and fittings

4.4.1 Every outlet pipe from a fuel oil tank shall be fitted with a shut-off valve.

For a tank situated above the double bottom, the valve shall be secured to the tank itself. Short distance pieces of rigid construction are acceptable.

Where an inlet pipe is connected below the liquid level, a shut-off valve or non-return valve at the tank shall be fitted.

Interpretation:

For filling lines entering at the top of a tank and with inside extension towards the bottom, air holes should be drilled in the pipe near the penetration in order to avoid the siphoning effect.

Oil piping valve arrangement is also affected by requirements for oil fuel tank protection. Reference is made to MARPOL Annex I Reg. 12A.9.

------------------ end of Interpretation ------------------

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 If oil gauges of glass are used for ascertaining the level of oil in storage, settling, or daily service tanks for fuel oil or lubricating oil, the glasses shall be of heat resisting material, suitably protected and fitted with self-closing cocks at the lower and upper ends, if the connections to the tanks are below the maximum oil level. The gauges shall be adequately supported.

4.5 Remotely controlled shut-off arrangement for fuel oil tanks

4.5.1 In the engine room, fuel oil valves on tanks shall be “quick-acting shut-off valves”, arranged for remote operation. The operation shall be carried out from a central position outside the engine room and at a safe distance from skylights and other openings to engine and boiler room.

Interpretation:

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

This is not applicable for valves closed during normal service, valves on double bottom tanks or valves on tanks less than 0.5 m³.

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

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.

4.5.2 Every oil fuel suction pipe, which is led into the engine room from a tank situated above the double bottom outside this space, is also to 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.

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

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

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.

4.7.2 For auxiliary engines one single fuel oil filter for each engine may be accepted.

4.7.3 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 is to 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.

4.8.2 Precautions shall be taken against overflow of oil from the lowest situated drip trays.

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 class notation E0, 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.

5 Thermal oil systems
Thermal oil systems shall be arranged and installed in accordance with requirements given in the DNV Rules for ships Pt.4 Ch.7.

6 Feed water and condensate 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 the DNV Rules for ships Pt.4 Ch.7 Sec.6.

6.2 Feed water heating

6.2.1 For steam boilers with working pressure above 7 bar arrangements for preheating and deaeration of the feed-water before entering the boiler shall be provided.

6.2.2 The preheating 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 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
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.

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.

7.3 Safety valves
The discharge from safety valves shall be to a point where hazard is not created, see the DNV Rules for ships Pt.4 Ch.7 Sec.6.

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 DNV Rules for ships Pt.4 Ch.7 Sec.6).

8 Hydraulic systems

8.1 General

8.1.1 The redundancy requirement in [1.1.1] 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 the DNV Rules for ships Pt.4 Ch.14.

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 DNV Approval Programme No.5-778.93.

8.4 Accumulators

8.4.1 Hydraulic accumulators of the gas or hydraulic fluid type having

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shall comply with the DNV Rules for ships 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 the DNV Rules for ships 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.

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

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 [1.1.1] 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.

9.2 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, 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 flame retardancy. 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 Reduction valves and filters shall be duplicated when serving more than one function (e.g. more than one control loop).

9.2.6 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.

9.2.7 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 DNV Rules for ships 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 and engines for other purposes</td>
<td>3 starts each</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 [10.2.4] 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.

11.1.2 There shall be independent ventilation systems for hazardous and non-hazardous areas.

11.1.3 Non-hazardous enclosed spaces shall be ventilated with over pressure in relation to hazardous areas.

11.1.4 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 [1.1.5].

11.2 Accommodation and control stations

The HVAC system with air intakes should be so located and constructed such 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 should 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.

Guidance note:
Attention should be paid for specific requirements of engine room ventilation under ESD for DP units, (see DNVGL-OS-A101, Ch.2 Sec.6 [4.2] and Sec.7 [4.4] for respectively drilling units and FPSOs)

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

11.3.2 In order to meet these requirements, the air should 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.

Interpretation:

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 Interpretation --------------

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 [1.1.1].

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

Interpretation:

The positive pressure should normally not exceed 50 Pa.

-------------- end of Interpretation --------------

11.3.7 The purifier room should 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 D8.3.2)

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.

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 and comply with SOLAS Reg. II-2/16 with respect to fire integrity.

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 is to ensure a good air circulation in all spaces, and in particular ensure that there is no possibility of formation of gas pockets in the room.

12.2.2 Gas turbines and gas handling machinery (e.g. compressors) are normally to be enclosed in an enclosure with minimum A-0 fire rating.

12.2.3 Inside the enclosure, adequate ventilation is always to be present. 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). Refer to DNVGL-OS-A101 Ch.2 Sec.3 [3.5] for reliability of ventilation air supply (redundancy of fans and power supply).

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 are not to 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:
The tangential membrane stress of a straight pipe is not to 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.

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

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 is also to be pressure tested to show 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.

\[
p^* = p_0 \cdot \left( \frac{\frac{2}{k}}{k+1} \right)^{\frac{k}{k-1}}
\]

\( p_0 \) = maximum working pressure of the inner pipe

\( k = \frac{C_p}{C_v} \) constant pressure specific heat divided by the specific volume specific heat

\( k = 1.31 \) for CH₄

Figure 1 Example of gas supply to gas turbine

Figure 2 Example of gas supply to boiler
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 are normally to 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). Single block and bleed isolation may be accepted for short supply lines, if this is in compliance with the owners isolation strategy.

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, must 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 the DNV Rules for ships Pt.5 Ch.5 Sec.16 and Pt.6 Ch.13.

12.7.2 The requirements for gas supply shall in general be as required in [12.2] and [12.3].
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
— 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
  — boilers and steam piping systems
  — compressed gases where \( pV \geq 150 \text{kNm} \)
    \( p = \text{design pressure in kN/m}^2 \)
    \( V = \text{pressure vessel volume in m}^3 \)
— firing and combustion installations.

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 requirements as given in the DNV Rules for ships shall be used. Internationally recognised codes and standards may be accepted on a case by case basis.

Guidance note:
The above requirements include both the technical, procedural and certification requirements from the Rules.

2.2 Propulsion and auxiliary machinery

2.2.1 For combustion engines in hazardous areas, see DNVGL-OS-A101, Ch.2 Sec.2 [4.3].

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
— exhaust outlet is located in a non-hazardous area
— combustion air inlet is located in a non-hazardous area
— automatic shut down is arranged to prevent overspeeding in the event of ingestion of flammable gas.
2.2.3 Efficient spark preventing equipment shall be fitted to the exhaust from all combustion engines and equipment, except gas turbines. A means shall be provided to give warning of failure of water supply to water-cooled spark preventing equipment.

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-E301.

2.4 Steering machinery
2.4.1 For requirements for steering machinery for ship-shaped units see the DNV Rules for ships Pt.4 Ch.14.

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.

3.1.2 The jack house frame, fixation system and the welding connection between rack and leg structure are dealt with in DNVGL-OS-C104 and DNVGL-OS-C201.

3.1.3 Structure
After this introductionary part, including documentation requirements, 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.

3.1.4 Documentation requirements
For documentation requirements for classification see Ch.3.

3.1.5 Failure mode and effect analysis
A failure mode and effect analysis (FMEA) according to DNVGL-OS-D202, Ch.3 Sec.1 Table 1-4 is to be carried out.

3.1.6 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)

3.1.7 The elements in the load-time spectrum listed in [3.1.6] (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.

3.1.8 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 [3.1.6]. Design safety factors etc. are valid for all foreseen operating conditions. 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 are to satisfy the requirements given in DNVGL-OS-B101 Ch.2 Sec.3 Table B2 and Sec.4 Table B2. 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) are to 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 In case of single failures, the jacking systems shall be designed such that repair (incl. minor replacements) is possible within 3 hrs.

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 L₁₀a (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 L₁₀a, 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 are to be documented. Extent of additional documentation to be determined by FMEA and novelty of design. Possibilities for replacement of these flexible mountings are to 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 is to 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 will apply.

3.2.17 In case of failure in the control system, jacking operations shall be stopped or fail to a safe position.

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 should be operable from a central jacking control station.
(See MODU code 4.14.2)

3.2.20 A communication system should 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 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.

(this includes requirements in 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 are to 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 An interlock shall be provided between electric motors and fixation rack system (if any), 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 DNV Classification Note 41.2. 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 (but due consideration shall be given to 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 3.3.7 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 Appendix C in DNV Classification Note 41.2.
3.3.11 NDT requirements for pinions, unless otherwise agreed with the manufacturer, are to be according to DNV Rules for Ships Pt.4 Ch.2 Sec.3 A200. 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.

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 DNV Rules for ships Pt.4 Ch.4, or other international standards to be agreed with society.

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 the DNV Classification Note 41.4 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.

3.3.20 The brake is to 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 only on pneumatic principles. General design requirements for the pneumatic system are described 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 are to be divided in several groups which are to be separately supplied from the compressed air system providing the contact pressure and for which the actual air pressure has to be monitored. If one group fails the groups remaining operable shall be capable of a holding capacity of 1.0 of the design load. Normally the fixed gripper and the movable gripper shall be provided with a group of rubber block rings. The movable gripper is connected to the hull structure of the unit via at least two hydraulic or pneumatic rams.

3.5.4 The control system has to permanently monitor the air pressure of the different rubber ring groups and automatically hold the pre-set air pressure. If there is the tendency that the air pressure of a group can only be kept by permanent operation of the compressors, a visible and audible alarm shall be activated. It has to be safely avoided, that all groups of rubber block rings get into a situation without compressed air at the same time.

3.5.5 The assumed friction coefficient between the rubber blocks and the shell of the tubular leg has to be agreed with DNV GL. To maintain this coefficient during practical operation, the shell of the tube has to be kept clean and free of oil or grease, etc. A cleaning device at the upper and lower end of a rubber block system is recommended. Before every lifting or lowering operation a check of the leg surface shall be done by the operating personnel.

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, WORKMANNSHIP, AND TESTING

1 General

1.1 Objectives
The section addresses joining quality and testing requirements which are 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 which have been 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 to 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.

2.3 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.
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.

2.4.3 For austenitic stainless steel heat treatment after welding is not normally required.

2.4.4 For other alloy steel grades the necessary heat treatment after welding shall be specially considered.

2.4.5 Stress relieving heat treatment shall be applied after welding, other than oxy-acetylene welding, as indicated in Table 3.

2.4.6 Heat treatment for oxy-acetylene welding shall be as indicated in Table 2, unless alternative treatment is clearly applicable.

---

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></td>
<td></td>
</tr>
<tr>
<td>$C + \frac{Mn}{6} \leq 0.40$</td>
<td>≥ 20 2)</td>
<td>50</td>
</tr>
<tr>
<td>C and C/Mn steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C + \frac{Mn}{6} &gt; 0.40$</td>
<td>≥ 20 2)</td>
<td>100</td>
</tr>
<tr>
<td>0.3 Mo</td>
<td>&gt; 13</td>
<td>100</td>
</tr>
<tr>
<td>1 Cr 0.5 Mo</td>
<td>&lt; 13</td>
<td>100</td>
</tr>
<tr>
<td>≥ 13</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>2.25 Cr 1 Mo and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5Cr 0.5 Mo 0.25 V 1)</td>
<td>&lt; 13</td>
<td>150</td>
</tr>
<tr>
<td>≥ 13</td>
<td>200</td>
<td></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.
2.4.7 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.

2.4.8 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.

2.5 Non-destructive testing

2.5.1 Both sides of all welded piping joints shall, wherever possible, be visually examined. 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 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, Tempering 640 to 720</td>
</tr>
<tr>
<td>2.25 Cr 1 Mo</td>
<td>Normalising 900 to 960, Tempering 650 to 780</td>
</tr>
<tr>
<td>0.5 Cr 0.5 Mo 0.25V</td>
<td>Normalising 930 to 980, Tempering 670 to 720</td>
</tr>
</tbody>
</table>

### 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 0.5Cr 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.

### 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>
</tbody>
</table>
2.5.2 A recognised alternative ultrasonic testing (UT) procedure may upon special consideration be applied in lieu of radiographic testing when the conditions are such that a comparable level of weld quality is assured.

2.5.3 For non-magnetic materials, dye-penetrant testing (PT) shall be used in lieu of magnetic particle examination.

2.5.4 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.

2.5.5 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.

2.5.6 The results from surface examination (e.g. MT, PT) are to satisfy the requirements of level B of ISO 5817.

2.5.7 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.

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:

   $\eta = 2 \frac{D_{\text{max}} - D_{\text{min}}}{D_{\text{max}} + D_{\text{min}}} \cdot 100 \%$

   $D = \text{outer pipe diameter}.$

   ---------------- end of Interpretation  ----------------

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 [3.4.16].

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 the hot forming is performed outside the above temperature range, a subsequent new heat treatment in accordance with Table 2 is generally 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/mm²).

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 should 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 over-torquing bolts shall not be performed.

5.3.3 The joining or bonding procedure should 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 may require re-qualification of the procedure.

5.3.5 The pipe manufacturer should 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 [3.10.9].

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.

5.4.3 Pipes and fittings should preferably be homogeneously conductive.
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:

\[
P_{H} = 1.5 \sigma \]

\[
P_{H} \quad = \quad \text{test pressure in bar}
\]

\[
P \quad = \quad \text{design pressure in bar as defined in Sec.2 [3.4.2]}
\]

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 \(p\):

\[
P_{H} = 1.5 \frac{\sigma_{100}}{\sigma_{t}} p
\]

\[
\sigma_{100} \quad = \quad \text{permissible stress at 100°C.}
\]

\[
\sigma_{t} \quad = \quad \text{permissible stress at the design temperature.}
\]

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.

**6.1.2** Pressure testing of small bore pipes (less than 15 mm D) need not be undertaken where not considered appropriate with respect to the application.

**6.1.3** 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 5.

Table 5 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 maximum working 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 maximum working pressure, minimum 4 bar</td>
</tr>
<tr>
<td>Class III pipelines for steam, compressed air and feed water</td>
<td></td>
</tr>
<tr>
<td>Hydraulic piping</td>
<td>1.5 maximum working pressure. Test pressure need not exceed working pressure by more than 70 bar</td>
</tr>
<tr>
<td>Piping systems made from non-metallic material</td>
<td>1.5 maximum working pressure, minimum 6 bar, minimum duration 1 hour</td>
</tr>
</tbody>
</table>

(See ASME B31.3, 345.1)

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.

6.2.3 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.

7 Functional testing

All piping systems shall be properly flushed, checked for leakage and functionally tested under working conditions.
CHAPTER 3 CERTIFICATION AND CLASSIFICATION

SECTION 1 CERTIFICATION AND 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>No.</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>
</tbody>
</table>

1.2 Applicable requirements

1.2.1 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.

1.2.2 Requirements applicable only for vessels with the voluntary notation ES can be found in the following Offshore Standards.

Table 2  DNV GL Offshore Standards including ES requirements

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNVGL-OS-A101</td>
<td>Safety principles and arrangements</td>
</tr>
<tr>
<td>DNVGL-OS-D101</td>
<td>Marine and machinery systems and equipment</td>
</tr>
<tr>
<td>DNVGL-OS-D202</td>
<td>Automation, safety, and telecommunication systems</td>
</tr>
<tr>
<td>DNVGL-OS-D301</td>
<td>Fire protection</td>
</tr>
</tbody>
</table>

1.2.3 Requirements applicable only for vessels with the voluntary notation ES as given in this standard are requirements on refrigeration plants given in Ch 2 Sec 1 [1.11].

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 for classification shall be in accordance with the NPS DocReq (DNV GL Nauticus Production System for documentation requirements) and DNVGL-CG-0168

1.4.2 Jacking systems
For jacking systems the following documents are normally expected for approval:

— description and general layout plans of the jacking system
— rack and pinion system:
  — detailed drawings of gear elements
  — detailed drawings of rack and pinion with tooth geometry
  — drawings of power transmitting parts, shafts, bearings, couplings and casings, brakes
  — foundation drawings for the gears system drawings of hydraulic systems, if applicable
  — single line diagram for electric system, if applicable
  — gear data sheet (ref. DNV GL Form 71.10a)
— ram and pin system:
  — detailed drawing of hydraulic cylinders and control valves as required in 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).

2 Certification of materials and components

2.1 Principles
2.1.1 Marine and machinery systems and equipment will be certified or classified based on the following main activities:
— design verification
2.1.2 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.

2.1.3 Components shall be certified consistent with their function and importance for safety. The principles of categorisation of component certification are given in the relevant Rules for MOU, see Table 1.

2.2 Certificate types

2.2.1 DNV GL defines three levels of documentation depending on importance of equipment and experience gained in service as given in [2.2.2].

2.2.2 Test report (TR) is a document signed by the manufacturer which states:

— conformity with the rule requirements
— that testing is carried out on samples from the current production of equal products.

The manufacturer is to have a quality system that is suitable for the kind of certified product. The surveyor is to check that the most important elements of this quality system are implemented and may carry out random inspection at any time. The products shall be marked to be traceable to the test report.

Works Certificate (W) is a document signed by the manufacturer which states:

— conformity with the rule or standard requirements
— that the tests are carried out on the certified product itself
— that the tests are made on samples taken from the certified product itself
— that the tests are witnessed and signed by a qualified department.

The manufacturer is to have a quality system that is suitable for the kind of certified product. The surveyor is to check that the most important elements of this quality system are implemented and may carry out random inspections at any time. The component shall be marked to be traceable to the work certificate.

DNV GL Product Certificate (VL) is a document signed by a DNV GL surveyor which states:

— conformity with the rule requirements
— that the tests are carried out on the certified product itself
— that the tests are made on samples taken from the certified product itself
— that the tests are made in the presence of a DNV GL surveyor or in accordance with special agreements.

The product shall be stamped with a special VL-stamp traceable to the certificate.

Guidance note:
The terms VL Certificate, Works Certificate, and Test Report used here refer to a product certificate rather than a material certificate.

A DNV GL Product Certificate (VL) may be delivered with material certified to a lower level than a DNV GL Material Certificate (VL) or ISO 10474 Certificate Type 3.2. The level of material certification is agreed as part of the certification process.

2.3 Categorisation of equipment and components

2.3.1 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.

2.3.2 Equipment may be categorised into two main categories, Category I, for which a DNV GL Product Certificate (VL) is required or Category II, for which manufacturer certification (W or TR) will be accepted.

2.3.3 Category I is subdivided into three subcategories depending on whether or not design review is carried out or whether an extensive fabrication survey is required. See Table 3.
2.3.4 Category II is subdivided into two subcategories depending on whether the manufacturer documentation required is based on a sample of similar products or the actual product to be delivered. See Table 3.

Table 3  Equipment categorisation

<table>
<thead>
<tr>
<th>Scope</th>
<th>Cat IA</th>
<th>Cat IB</th>
<th>Cat IC</th>
<th>Cat IIA</th>
<th>Cat IIB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certificate / Document</td>
<td>D S2 R2</td>
<td>D S1 R2</td>
<td>S1 R2</td>
<td>R2</td>
<td>R1</td>
</tr>
</tbody>
</table>

- **D**: Design review
- **S1**: Witness of final testing of completed product
- **S2**: Survey during construction and witness of final testing of completed product
- **R1**: Review of manufacturers documentation (typical for product)
- **R2**: Review of manufacturers documentation (specific to product)

2.4 Certification requirements under this standard

2.4.1 Certification requirements for miscellaneous mechanical components are given in Table 4.

Table 4  Certification of miscellaneous machinery and mechanical components

<table>
<thead>
<tr>
<th>Item</th>
<th>Certification category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jacking machinery</td>
<td>IA</td>
</tr>
<tr>
<td>Turret bearings</td>
<td>IA</td>
</tr>
<tr>
<td>Boiler</td>
<td>IA</td>
</tr>
<tr>
<td>Condenser</td>
<td>IIA</td>
</tr>
<tr>
<td>Boiler heat exchanger</td>
<td>IA</td>
</tr>
<tr>
<td>Pumps for boiler</td>
<td>IC</td>
</tr>
<tr>
<td>Boiler PSV</td>
<td>IC</td>
</tr>
<tr>
<td>Boiler spark arrestor</td>
<td>IIB</td>
</tr>
<tr>
<td>Winches</td>
<td>IA</td>
</tr>
<tr>
<td>Hydraulic Cylinders $pD &gt; 20000$ 1)</td>
<td>IA</td>
</tr>
<tr>
<td>Hydraulic Cylinders $pD \leq 20000$</td>
<td>IIA</td>
</tr>
<tr>
<td>Compressor 2)</td>
<td></td>
</tr>
</tbody>
</table>

1) Hydraulic cylinders for cleating and manoeuvring of watertight doors and hatches shall be delivered with certificate of category IA regardless of pressure and size. Cleating cylinders where the locking mechanism is placed inside the cylinder are to be type approved.

2) Compressors to be certified in accordance with DNV Rules for ships Pt.4 Ch.5 Sec.4.

$p = \text{design pressure (bar)}$

$D = \text{internal diameter of cylinder tube (mm)}$

2.4.2 Piping and piping components are to be delivered with material certification in accordance with Ch.2 Sec.2 Table 5. Where the requirement calls for witness by 3rd party (Certificate Type 3.2) this shall be carried out by DNV GL.

2.4.3 Certification requirements for pressure vessels are given in Table 5.

Table 5  Categories for pressure containing equipment and storage vessels 1)

<table>
<thead>
<tr>
<th>Property</th>
<th>Conditions</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1 &lt; P \leq \frac{20000}{D_i + 1000}$</td>
<td>I 2)</td>
</tr>
<tr>
<td>Pressure</td>
<td>$P &gt; \frac{20000}{D_i + 1000}$</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>Vacuum or external pressure</td>
<td>X</td>
</tr>
</tbody>
</table>
2.4.4 Certification requirements for steering and propulsion components are given in Table 6.

Table 6 Certification of components for steering and propulsion systems

<table>
<thead>
<tr>
<th>Item</th>
<th>Certification category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thruster including receptacles</td>
<td>IA</td>
</tr>
<tr>
<td>Propeller</td>
<td>IA</td>
</tr>
<tr>
<td>Steering gear</td>
<td>IA</td>
</tr>
<tr>
<td>Rudder</td>
<td>IA</td>
</tr>
<tr>
<td>Diesel engine</td>
<td>IA</td>
</tr>
<tr>
<td>Gas turbine</td>
<td>IA</td>
</tr>
</tbody>
</table>

2.4.5 For equipment in piping systems serving essential and important functions on self-propelled units equipment as listed in DNV Rules for ships Pt.4 Ch.6 Sec.5 shall be delivered with a VL Certificate.

2.4.6 For equipment on other installations, certification in accordance with Table 7 will be required for the listed equipment.

2.4.7 Electrical equipment should be certified in accordance with DNVGL-OS-D201 Ch.3 Sec.1 [3.4].

Table 7 Certification of components in marine piping systems

<table>
<thead>
<tr>
<th>Item</th>
<th>Certification category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping system items for main engine or main power</td>
<td></td>
</tr>
<tr>
<td>Fuel oil transfer pump</td>
<td>IC</td>
</tr>
<tr>
<td>Lube oil pump</td>
<td>IC</td>
</tr>
<tr>
<td>Cooling system pump unit</td>
<td>IC</td>
</tr>
<tr>
<td>Lube oil heat exchanger</td>
<td>IC</td>
</tr>
<tr>
<td>Fuel oil heat exchanger</td>
<td>IC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Valves</th>
<th>Certification category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves for sea inlet or discharge with DN &gt;100 mm</td>
<td>IC</td>
</tr>
<tr>
<td>Valves with DN &gt;100 mm and p&gt;16 bar</td>
<td>IC</td>
</tr>
<tr>
<td>Non-standard valves</td>
<td>IB</td>
</tr>
</tbody>
</table>
3 Survey during construction

3.1 General

3.1.1 This subsection describes surveys during construction of marine and machinery systems and components.

3.1.2 General requirements for surveying during construction are stated in the relevant DNV GL Rules for MOU, see Table 1.

Table 7 Certification of components in marine piping systems (Continued)

<table>
<thead>
<tr>
<th>Item</th>
<th>Certification category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressed air systems</td>
<td></td>
</tr>
<tr>
<td>Starting air compressors</td>
<td>IC</td>
</tr>
<tr>
<td>Pressure relief valves</td>
<td>IIA</td>
</tr>
<tr>
<td>Ballast system</td>
<td></td>
</tr>
<tr>
<td>Ballast pumps</td>
<td>IC</td>
</tr>
<tr>
<td>Bilge and drain system</td>
<td></td>
</tr>
<tr>
<td>Bilge pumps</td>
<td>IC</td>
</tr>
<tr>
<td>Bilge ejectors</td>
<td>IIA</td>
</tr>
<tr>
<td>Strainers</td>
<td>IIB</td>
</tr>
<tr>
<td>Strams and rose boxes</td>
<td>IIB</td>
</tr>
<tr>
<td>Air and sounding systems</td>
<td></td>
</tr>
<tr>
<td>Air vent heads</td>
<td>IB</td>
</tr>
<tr>
<td>Tank level indicators</td>
<td>IIA</td>
</tr>
<tr>
<td>Sounding control panel</td>
<td>IB</td>
</tr>
<tr>
<td>Striking plates</td>
<td>IIB</td>
</tr>
<tr>
<td>Sounding rods</td>
<td>IIB</td>
</tr>
<tr>
<td>Hydraulic control of safety critical valves etc.</td>
<td></td>
</tr>
<tr>
<td>Hydraulic control panel</td>
<td>IB</td>
</tr>
<tr>
<td>Pumps in hydraulic control system</td>
<td>IC</td>
</tr>
<tr>
<td>Hydraulic power pack</td>
<td>IIA</td>
</tr>
<tr>
<td>Accumulators PV≥1.5 (See Table 5 for definitions)</td>
<td>IB</td>
</tr>
<tr>
<td>Accumulators (others)</td>
<td>IIA</td>
</tr>
<tr>
<td>Tanks for hydraulic fluid</td>
<td>IIB</td>
</tr>
</tbody>
</table>

Table 8 Certification of control and monitoring systems

<table>
<thead>
<tr>
<th>Item</th>
<th>Certification category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steering and propulsion systems (if relevant)</td>
<td>IC</td>
</tr>
<tr>
<td>Main engine or main power</td>
<td>IC</td>
</tr>
<tr>
<td>Ballast system</td>
<td>IC</td>
</tr>
<tr>
<td>Bilge system</td>
<td>IC</td>
</tr>
<tr>
<td>Air and sounding (level monitoring)</td>
<td>IC</td>
</tr>
<tr>
<td>Control of safety critical valves (hydraulically or pneumatically operated not covered by other certified control systems)</td>
<td>IC</td>
</tr>
<tr>
<td>Jacking machinery (if installed)</td>
<td>IC</td>
</tr>
<tr>
<td>Boiler (if installed)</td>
<td>IC</td>
</tr>
<tr>
<td>Winches (dependent on class notation, e.g. POSMOOR)</td>
<td>IC</td>
</tr>
<tr>
<td>Leak detection system (if relevant for unit, see also Ch.2 Sec.3 [6.5])</td>
<td>IC</td>
</tr>
</tbody>
</table>

3 Survey during construction

3.1 General

3.1.1 This subsection describes surveys during construction of marine and machinery systems and components.

3.1.2 General requirements for surveying during construction are stated in the relevant DNV GL Rules for MOU, see Table 1.
3.2 Quality assurance and quality control

3.2.1 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.

3.2.2 Contractors who do not meet the requirement in [3.2.1] will be subject to special consideration in order to verify that products satisfy the relevant requirements.

3.2.3 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.

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

3.3 Materials

3.3.1 Welded pipes may be accepted as seamless pipes only where supplied by a DNV GL approved manufacturer for the production of such pipes.

3.3.2 Grey cast iron shall only be accepted for hydraulic piping systems after special consideration on a case by case basis.

3.3.3 Use of nodular cast iron for piping shall be subject to special DNV GL approval on a case by case basis.

3.3.4 Design conditions for plastic pipes containing media other than water, shall be supplied to DNV GL for approval.

3.3.5 Electrically conductive piping for use in gas hazardous areas shall be DNV GL type approved (See Ch.2 Sec.2 [2.5.6]).

3.4 Welding and welder qualification

3.4.1 Approval of welders shall be in accordance with DNVGL-OS-C401 or the applied design code.

3.4.2 Welders already approved to another corresponding code than the design code may be accepted if properly documented.

3.4.3 WPS shall be approved by DNV GL.

3.4.4 The extent of the welding procedure test shall be agreed upon with DNV GL before the work is started.

3.4.5 A welding production test (WPT) may be required by the surveyor during fabrication to verify that the produced welds are of acceptable quality.

3.4.6 Welding repairs shall be performed according to an repair procedure approved by DNV GL.

3.4.7 Socket welded joints and slip on sleeves shall be subject to special DNV GL approval on a case by case basis.

3.4.8 Local PWHT may be performed on simple joints when following an approved procedure. The procedure shall be approved by DNV GL.

3.4.9 The heat treatment procedure in connection with forming and/or welding shall be approved if not covered by the applied code or standard.

3.4.10 The heat treatment procedure in connection with pipe bending shall be approved if not covered by the applied code or standard.

3.4.11 Omission of heat relieving treatment for C and C-Mn steels up to 30 mm thickness shall be subject to special DNV GL approval.

3.4.12 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.
3.4.13 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.

4 Survey during installation and commissioning

4.1 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.

4.2 Mechanical completion
Before commissioning of systems starts, all items of pipework and equipment shall be checked for compliance with approved documentation and commissioning procedures.

4.3 Functional testing
During commissioning, the systems shall be functionally tested, as practicable in accordance with reviewed procedures.

4.4 Specific requirements for jacking systems

4.4.1 General
The testing of the jacking gear system shall in general consist of workshop testing, inspection after installation and testing on board.

4.4.2 Workshop testing
Spin test and contact pattern test shall be carried out according to the DNV Rules for ships Pt.4 Ch.4. Sec 2 D.

4.4.3 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 (with reference to DNV Rules for ships Pt.4 Ch.4 H):

- shaft alignment, see DNV Rules for ships Pt.4 Ch.4 Sec.1 H300
- 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.

4.4.4 Jacking trials
Jacking trial shall performed according to an approved jacking trial plan and as covered by the QSP. The trial shall cover the correct functioning of the jacking machinery and other relevant items.

The jacking machinery shall be tested with the highest specified design lifting 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 are to 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 to be surveyed to the satisfaction of the surveyor.
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 and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16 000 professionals are dedicated to helping our customers make the world safer, smarter and greener.