

OFFSHORE STANDARD

DNVGL-OS-E101

Edition July 2015

Drilling plant



FOREWORD

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

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CHANGES – CURRENT

General

This document supersedes DNV-OS-E101, October 2013.

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 2015

- 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 Drilling systems and equipment

- [3.2.2] and [3.5.2]: First item moved to separate clause [3.5.2].
- [6.4]: Moved item 3, including Guidance note, to [3.2.1] item 10.
- [7.3.8]: Updated guidance note. Removal of first paragraph, second sentence since this is covered by rule requirement [7.3.6] item 2.

- Ch.3 Sec.3 System and equipment certification

- [1.1]: Removed "or other recognized standards" in second sentence.
- Table 6: Detailing certification requirements for standpipe manifold and cement.

Editorial corrections

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

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CHAPTER 1 INTRODUCTION

SECTION 1 INTRODUCTION

1 General

1.1 Introduction

1.1.1 This Offshore Standard contains criteria, technical requirements and guidance on design, construction and commissioning of drilling facilities and associated equipment

Criteria, technical requirements and guidance related to workover and well intervention facilities and associated equipment are provided in [App.A](#).

1.1.2 The standard is applicable to drilling facilities located on floating offshore units and on fixed offshore installations of various types.

[App.A](#) is applicable to workover and well intervention facilities located on floating offshore units and on fixed offshore installations of various types.

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

1.1.4 This standard is provided as a facilities standard, and is supplementary to other discipline specific standards for structures, electrical, materials, components, etc. as indicated in [Table 1](#).

Table 1 DNV GL Offshore standards and other DNV GL/ DNV references

<i>Reference</i>	<i>Title</i>
DNVGL-OS-A101	Safety principles and arrangement
DNVGL-OS-B101	Metallic materials
DNVGL-OS-C101	Design of offshore steel structures, general - LRFD method
DNVGL-OS-C102	Structural design of offshore ships
DNVGL-OS-C103	Structural design of column stabilised units - LRFD method
DNVGL-OS-C104	Structural design of self elevating units - LRFD method
DNVGL-OS-C105	Structural design of TLPs - LRFD method
DNVGL-OS-C106	Structural design of deep draught floating units
DNVGL-OS-C201	Structural design of offshore units - WSD method
DNVGL-OS-C401	Fabrication and testing of offshore structures
DNVGL-OS-D101	Marine and machinery systems and equipment
DNVGL-OS-D201	Electrical installations
DNVGL-OS-D202	Automation, safety and telecommunication systems
DNVGL-OS-D301	Fire protection
DNVGL-OS-E201	Oil and gas processing systems (Only applicable for well testing)
DNV-OS-F201	Dynamic Risers
DNV-RP-A203	Technology Qualification
DNV-RP-C205	Environmental Conditions and Environmental Loads
DNV Standard for Certification No. 2.22	Lifting Appliances
DNV-RP-D101	Structural Analysis of Piping Systems
DNV-RP-O501	Erosive Wear in Piping Systems

Table 1 DNV GL Offshore standards and other DNV GL/ DNV references

Reference	Title
DNV Standard for Certification No 2.4	Environmental Test Specification for Instrumentation and Automation Equipment
DNV Standard for Certification No. 2.7.3	Portable Offshore Units
DNV Standard for Certification No 2.9	Approval Programme No. 5-778.93 Hydraulic Cylinders
DNV Rules for Lifts	Rules for Certification of Lifts in Ships, Mobile Offshore Units and Offshore Installations

1.2 Objectives

The objectives of this standard are to:

- provide an internationally acceptable standard of safety for drilling facilities by defining minimum requirements for the design, materials, construction, testing and commissioning of such facilities
- serve as a reference document in contractual matters between purchaser and contractor
- serve as a guideline for designers, purchasers and contractors
- specify procedures and requirements for drilling facilities subject to DNV GL certification and classification.

1.3 Organisation of this standard

This standard is divided into three main chapters:

Ch.1: General information, scope, definitions and references.

Ch.2: Technical provisions for drilling facilities for general application.

Ch.3: Specific procedures and requirements applicable for certification and classification of drilling facilities in accordance with this standard.

This standard has one appendix:

App.A: Workover and well intervention systems and equipment.

1.4 Scope and application

1.4.1 This standard is applicable for design and construction of drilling facilities for use on all types of fixed and floating offshore installations.

1.4.2 The standard should be applied from concept design through to final construction, including major modifications.

1.4.3 The technical and procedural/certification requirements as given in this standard apply to temporary installed equipment on board as well.

Guidance note:

See DNV GL Offshore Technical Guidance OTG-07 for details.

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1.4.4 Requirements presented are minimum requirements to be satisfied, but should take account of available technological and technical improvements at the time of application. Prescriptive requirements are not intended to inhibit application of practicable improvements. Where the prescriptive requirements might no longer be suitable, verification shall be based on an agreed scheme of analysis that is separately worked out and approved.

1.4.5 Introduction of novel technology or designs (as mentioned in [1.4.4]) shall be preceded by a recognized qualification process.

Guidance note:

The process for qualification of new technology is for instance described in DNV-RP-A203.

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1.4.6 The requirements of this standard shall be supplemented where installation specific design or assessment shows that higher standards are more appropriate.

1.5 Deviation from the requirements

Without prejudice to [1.4.4], deviations from the requirements of this standard may only be substituted where shown to provide an equivalent or higher level of integrity or safety than under this standard. Any deviation or exemption from this standard shall be agreed and documented between all contracting parties.

2 Definitions

2.1 Verbal forms

Table 2 Verbal forms

Term	Definition
shall	verbal form used to indicate requirements strictly to be followed in order to conform to the document
should	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
may	verbal form used to indicate a course of action permissible within the limits of the document
agreement or by agreement	unless otherwise indicated, agreed in writing between manufacturer or contractor and purchaser

2.2 Definitions

Table 3 Definitions

Term	Definition
alarm	warning of abnormal condition and is a visual and/or audible signal, where the audible part normally calls the attention of personnel, and the visual part serves to identify the abnormal condition Guidance note: Both audible and visual part alone may serve both functions during special operating conditions. ---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
basic software	software necessary for the hardware to support the application software Guidance note: Basic software normally includes the operating system and additional general software necessary to support the general application software and project application software. ---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
computer	any programmable electronic system, including main-frame, mini-computer or micro-computer
computer based system serving an essential or important function	the function can be in operation without support from the computer system, i.e. the computer is not part of the function
computer based system as part of an essential or important function	the function cannot be in operation without support from the computer system, i.e. the computer is part of the function
computer task	a multiprocessing environment, one or more sequences of instructions treated by a control program as an element of work to be accomplished by a computer
contract or contracting parties	formal written agreement or parties who need to adhere to the formal written agreement

Table 3 Definitions (Continued)

Term	Definition
data communication links	<p>point to point links, instrument net and local area networks, normally used for inter computer communication on board vessels</p> <p>A data communication link includes all software and hardware necessary to support the data communication.</p> <p>Guidance note: For local area networks, this includes network controllers, network transducers, the cables and the network software on all nodes.</p> <p>---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---</p>
deep water	water depth exceeding 600 meters
defined accidental events	<p>events that could cause death or serious personal injury to personnel on board the installation, and that are controlled in order to meet risk acceptance criteria</p> <p>This includes events that could result in significant damage to the structure of the installation, loss of stability, or the need to evacuate the installation. Defined accidental events form one basis for defining dimensioning accidental loads.</p>
design pressure	<p>the maximum pressure for which the system is designed</p> <p>The set point of PSVs shall not exceed this pressure</p>
drilling facilities	areas containing systems and equipment required for drilling operations
drilling plant	equipment and systems necessary for safe drilling operations, but limited to the systems covered by this standard
dynamic MPD pressure control equipment	mechanical equipment used to dynamically adapt the annular hydraulic pressure profile in the well
equipment	all mechanical and structural components of which the drilling systems covered by this standard consist
equipment under control (EUC)	the mechanical equipment (machinery, pumps, valves, etc.) or environment (smoke, fire, waves, etc.) monitored and/or controlled by an instrumentation and automation system
essential function	generally defined as a function whose loss or failure could create an immediate danger to personnel, environment or the installation
fail safe	implies that a component or system goes to, or remains in, the mode which is deemed to be safest on failures in the system
failure	<p>in the context of this standard, an event causing one or both of the following effects:</p> <ul style="list-style-type: none"> — deterioration of functionality to such an extent that safety is significantly affected — loss of component or system function.
field instrumentation	<p>all instrumentation that forms an integral part of a process segment to maintain a function</p> <p>The field instrumentation includes:</p> <ul style="list-style-type: none"> — sensors, actuators, local control loops and related local processing as required to maintain local control and monitoring of the process segment — user interface for manual operation (when required) <p>Other equipment items do not, whether they are implemented locally or remotely, belong to the field of instrumentation. This applies to data communication and facilities for data acquisition and pre-processing of information utilised by remote systems.</p>
general application software	computer software performing general tasks related to a process equipment being controlled or monitored, rather than to the functioning of the computer itself
hazardous area	space in which a flammable atmosphere may be expected at such frequency that special precautions are required. Refer to reference codes for a complete definition including zones, etc.
independent systems	implies that there are no functional relationships between the systems and they cannot be subject to common mode failures
indications	the visual presentation of process equipment values or system status to a user
installation or drilling installation	<p>is a general term for floating and fixed structures, including facilities, which are intended for exploration, drilling, production, processing or storage of hydrocarbons or other related activities or fluids</p> <p>The term includes installations intended for accommodation of personnel engaged in these activities.</p>

Table 3 Definitions (Continued)

<i>Term</i>	<i>Definition</i>
instrument net	data communication within the field instrumentation connecting instruments in a network
integrated system	a combination of computer based systems which are interconnected in order to allow common access to sensor information and/or command or control
interlock system	a set of devices or keys that ensure that operations (e.g. opening and closing of valves) are carried out in the right sequence
important function	generally defined as a function which does not necessarily need to be continuously available, as even though a failure or non-availability of the function could impair the safety of personnel, environment or the installation, it would not create an immediate danger
local area network	data communication between the field instrumentation and the other parts of a system, and between different systems
managed pressure drilling, MPD	an adaptive drilling process used to more precisely control the annular pressure profile throughout the wellbore. MPD is per definition used for overbalanced drilling
maximum allowable working pressure (MAWP)	the maximum operating pressure of a system The MAWP cannot be higher than the design pressure.
maximum unavailable time	the maximum duration of time the function is allowed to be unavailable, i.e. the maximum permissible time lag involved in restoring lost function upon failure
minimum design temperature, MDT	minimum design operating or ambient start-up temperature The lowest predictable metal temperature occurring during normal operations including start-up and shut-down situations shall be used. (If no thermal insulation is fitted, then ambient temperature shall be used if this is lower than the temperature of the content).
MPD pressure control equipment	dynamic and static MPD pressure control equipment
MPD pressure control system	includes MPD controller unit, well monitoring system, and MPD pressure control equipment The respective system is used to control flow and pressures in the well system.
MPD system	a specific well system used for managed pressure drilling operations <i>See well system.</i>
multiplex, MUX, control system	a system utilizing electrical or optical conductors in an armoured subsea umbilical cable such that, on each conductor, multiple distinct functions are independently operated by dedicated serialized coded commands
node	process segment or a part of the system connected as part of the data communication link
non-important function	defined as a function which is neither essential/important, nor a safety function
non-redundant structure	<i>see special area or non-redundant structure</i>
operating conditions	conditions wherein a unit is on location for purposes of drilling or other similar operations and combined environmental and operational loading are within the appropriate design limits established for such operations The unit may be either afloat or supported on the sea bed as applicable.
point to point link	data communication between two dedicated nodes
pre-warning	indication of a process equipment or system state that needs attention
primary structure	structural elements that are essential to the overall integrity of the structure
primary well control	for overbalanced drilling (conventional drilling/mpd), primary well control is to continuously ensure that the hydraulic pressure in the well is maintained within the expected and verified drilling pressure window Guidance note: Primary well control involves the mud (with dedicated equipment to control flow and pressures) in the well system, mud processing, monitoring, and maintenance of the mud ---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
process	the result of the action done by the EUC, see equipment under control (EUC)
process segment	a collection of mechanical equipment with its related field instrumentation, e.g. a machinery or a piping system Process segments belonging to essential functions are referred to as essential.

Table 3 Definitions (Continued)

<i>Term</i>	<i>Definition</i>
project application software	computer software performing tasks related to the actual process equipment for a specific project
reference thickness	material thickness For weld regions the reference thickness is defined as the thickness of the plate determining the weld throat thickness.
rupture (or bursting) disc	a device designed to rupture or burst and relieve pressure at a defined pressure and rate The device will not close after being activated.
safe working load (SWL)	the maximum allowable mass to be lifted
safety factor	the relationship between maximum allowable stress level and a defined material property, normally specified minimum yield strength
safety function	a function which is provided to prevent, detect/warn of an accidental event/abnormal condition and/or mitigate its effects
safety shutdown	a safety action that will be initiated upon failure and shall result in shutdown of the process equipment or part of the process equipment in question
safety system	systems, including required utilities, which are provided to prevent, detect/warn of an accidental event/abnormal conditions and/or mitigate its effects Guidance note: 1) A safety system is a system that only performs safety functions. 2) Examples of safety systems related to drilling (other safety systems are given in DNVGL-OS-A101) <ul style="list-style-type: none">— PSD for well test— BOP/Diverter/Choke and Kill incl. control system— Safety logic unit for MPD— Other safety systems for drilling systems/equipment (e.g. emergency stop, overload protection, etc.). ---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
secondary structure	all structures that are not defined as primary, special or non-redundant
secondary well control	secondary well control is executed in those cases where primary well control has failed Secondary well control involves use of dedicated well control equipment and is performed as a minimum until primary well control is restored.
software module	assembly of code and data with a defined set of input and output, intended to accomplish a function and where verification of intended operation is possible through documentation and tests
special area or non-redundant structure	areas of primary structural elements with critical stress concentrations or members which are non-redundant
static mpd pressure control equipment	mechanical equipment used to isolate back pressure in the well
survival condition	condition during which a unit may be subjected to the most severe environmental loading for which the unit is designed Drilling or similar operations may have been discontinued due to the severity of the environmental loading. The unit may be either afloat or supported on the sea bed as applicable.
temporary equipment	equipment intended for use on installations for a limited time
transit condition	all unit movements from one geographical location to another
uninterruptible power supply (UPS)	device supplying output power in some limited time period after loss of input power with no interruption of the output power
unit	entity of hardware, software, or both
user	a human being that will use a system or device, e.g. captain, navigator, engineer, radio operator, stock-keeper, etc.
user input device (UID)	device from which a user may issue an input including handles, buttons, switches, keyboard, joystick, pointing device, voice sensor and other control actuators
utility systems	systems providing the installation with supporting functions Typical systems are cooling water, hot oil for heating, chemical systems for injection, instrument air and power generation system.

Table 3 Definitions (Continued)

<i>Term</i>	<i>Definition</i>
visual display unit (VDU)	area where information is displayed including indicator lamps or panels, instruments, mimic diagrams, Light Emitting Diode (LED) display, Cathode Ray Tube (CRT), and Liquid Crystal Display (LCD)
well barrier	an envelope of one or several dependent well barrier elements preventing a well incident
well barrier element	a technical or operational measure that is part of the realization of a well barrier A well barrier element can only be considered a well barrier for specified operations if it can be documented that the element will solely prevent a well incident within both expected and verified operational limits. Otherwise, a combination of several well barrier elements is required to obtain an accepted well barrier.
well control incident	loss of well control causing unintentional flow to surface, or between the well and formations/environment
well incident	unintentional flow to surface, between well/well construction and formations/environment, or between affected formation layers adjacent to the well
well system	a complete system for drilling which includes dedicated systems and equipment, in addition to the well construction and interfaces to the drilling unit
working load (suspended load)	the mass of the load lifted plus the mass of the accessories (e.g. sheave blocks, hooks, slings, etc.)
workstation	position at which one or several functions constituting a particular activity are carried out

2.3 Abbreviations

Abbreviations as shown in [Table 4](#) apply to this standard.

Table 4 Abbreviations

<i>Reference</i>	<i>Title</i>
ANSI	American National Standards Institute
API	American Petroleum Institute
APV	air pressure vessel
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing of Materials
BHP	bottom-hole pressure
BOP	blow out preventer
BS	British Standard (issued by British Standard Institution)
CMC	certification of materials and components
DIN	Deutsche Institut für Normung e.v
DP	dynamic position
DVR	design verification report
ECD	equivalent circulating density
EDS	emergency disconnect sequence/system
EQD	emergency quick disconnect
EDP	emergency disconnect package
EN	European de Normalisation
ESD	emergency shutdown
EUC	equipment under control
EWT	extended well testing
FEM	Fédération Européenne de la Manutention
F&G	fire and gas
HPHT	high pressure high temperature
HPU	hydraulic power unit
HVAC	heating, ventilation and air conditioning
IEC	International Electrotechnical Commission

Table 4 Abbreviations

<i>Reference</i>	<i>Title</i>
IMO	International Maritime Organisation
IP	Institute of Petroleum
ISO	International Organisation for Standardisation
LMRP	lower marine riser package
LRP	lower riser package
MODU	mobile offshore drilling unit
MPD	managed pressure drilling
MPE	magnetic particle examination
MWD	measure while drilling
NACE	National Association of Corrosion Engineers
NDE	normally de-energised
NDT	non-destructive testing
NE	normally energised
NS	Norwegian Standard (issued by Norwegian Standards Association)
OS	Offshore standard
PC	product certificate
PCV	pressure control valve
PSV	pressure safety (or relief) valve
PWD	pressure while drilling
PWHT	post weld heat treatment
RCD	rotating control device
RIC	report for incomplete certification
RP	Recommended practice
SG	specific gravity
SWL	safe working load
TEMA	tubular exchange manufacturers association
TLP	tension leg platform
UID	user input device
UPS	uninterruptible power supply
VDU	visual display unit
WT	well testing

3 Normative references

3.1 General

3.1.1 The requirements of this standard include carefully integrated references to internationally recognised codes and standards, as well as other DNV GL Offshore Standards. Except where only specific part(s) of a code or standard is referenced in this standard, or where otherwise agreed by all involved parties, all applicable requirements for the equipment system in question arising from the referenced code or standard shall apply.

3.1.2 Other *ad hoc* combination of codes or standards should only be made after proper consideration of the compatibility of the documents, and only where safety and sound engineering practice can be justified. Such selective (piecemeal) application of a code or standard shall be verified.

3.1.3 The international or national references as well as references to other DNV GL Offshore Standards frequently referred to in respective sections of this standard are shown in [Table 5](#) and [Table 1](#) respectively. In any instance of conflict between specific requirements of a reference standard and this standard, the

requirements of this standard shall apply.

Table 5 International or national references

<i>System</i>	<i>Reference No.</i>	<i>Title</i>
BOPs	API Spec 6A	Wellhead and Christmas Tree Equipment
	API Spec 16A	Drill Through Equipment
	API Spec 16D	Control Systems for Drilling Well Control Equipment
	API Standard 53	Blowout Prevention Equipment Systems for Drilling Operations
	ISO 10423	Petroleum and natural gas industries - Drilling and production equipment - Specification for valves, wellhead and Christmas tree equipment
Choke and kill systems	API Spec 16C	Choke and Kill Systems
Diverter systems	API RP 64	Diverter Systems Equipment and Operations
	API Spec 6D	Specification for Pipeline Valves
Marine risers	API Spec 16F	Specification for Marine Drilling Riser Equipment
	API Spec 16R	Marine Drilling Riser Couplings
	API RP 16Q	Design, Selection, Operation and Maintenance of Marine Drilling Riser Systems
	API Bul 16J	Comparison of Marine Drilling Riser Analyses
Drilling equipment	API Spec 7K	Drilling and Well Servicing Equipment
	API Spec 8C	Drilling and Production Hoisting Equipment (PSL1 and PSL2)
	API Spec 9A	Wire Rope
	API RP 7G/ ISO 10407	Petroleum and natural gas industries - Drilling and production equipment - Drill stem design and operating limits
	API RP 7L	Procedures for Inspection, Inspection, Maintenance, Repair, and Remanufacture of Drilling Equipment
	API RP 8B	Inspection, Maintenance, Repair, and Remanufacture of Hoisting Equipment
	API RP 9B	Application, Care and Use of Wire Rope for Oil Field Service
Pressure vessels, fired units and heat exchangers	ASME Boiler and Pressure Vessel Code	Section VIII, Division 1 and 2, Rules for Construction of Pressure Vessels
	ASME Boiler and Pressure Vessel Code	Section IV, Heating Boilers
	ASME Boiler and Pressure Vessel Code	Section I, Power Boilers
	PD 5500	Unfired Fusion Welded Pressure Vessels
	BS 2790	Specification for Design and Manufacture of Shell Boiler of Welded Construction
	BS 5045	Transportable gas containers
	TEMA	Tubular Exchangers Manufacturers Association standards
	API Std 530 / ISO 13704	Calculation of Heater Tube Thickness in Petroleum Refineries
Derrick	API Spec 4F	Drilling and Well Servicing Structures
	API RP 4G	Maintenance and Use of Drilling and Well Servicing Structures
Lifting appliances in general	FEM	Rules for the Design of Hoisting Appliances
Work over and well intervention equipment	ISO 13628-7	Design and operation of subsea production systems - Part 7 Completion/ workover riser systems
Piping	ANSI/ASME B31.3	Process Piping
	API RP 14E	Design and Installation of Offshore Production Platform Piping Systems
	API RP 17B	Flexible Pipe
Corrosion - hydrogen sulphide	NACE MR0175 / ISO 15156	Sulphide Stress Cracking Resistant Metallic Material

Table 5 International or national references (Continued)

<i>System</i>	<i>Reference No.</i>	<i>Title</i>
Miscellaneous	ANSI B2.1	Pipe Threads, General Purpose (Inch), (Except Dryseal)
	ISO 10418	Petroleum and natural gas industries - Offshore production platforms - Analysis, design, installation and testing of basic surface safety systems
	API RP 14C	Analysis, Design, Installation and Testing of Basic Surface Safety Systems on Offshore Production Platforms
	API RP 14J	Design and Hazards Analysis for Offshore Production Facilities
	API RP 505	Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1 and Zone 2
	ASTM 193	Alloy steel and stainless steel bolting materials for high temperature service
	EN 10204	Metallic Products - Type of Inspection Documents
	IEC 60092-504	Electrical installations in ships - Part 504: Special features - Control and instrumentation
	IEC 60529	Degrees of protection provided by enclosures (IP Code)
	IEC 60533	Electrical and electronic installations in ships - Electromagnetic compatibility
	IEC 60945	Maritime navigation and radio communication equipment and systems - General requirements - Methods of testing and required test results
	IP 15	Area classification code of Petroleum Installations
	ISO 898-1	Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs.
	ISO 898-2	Mechanical properties of fasteners - Part 2: Nuts with specified proof load values - Coarse thread

3.1.4 Other codes and standards may be applied provided that the alternative standard can be clearly shown to provide a comparable or higher safety level than under the requirements of this standard.

3.1.5 Any deviations, exceptions, and modifications to the design codes and standards shall be documented and agreed between all contracting parties.

3.1.6 The latest issue of the standards (as referred to in [Table 1](#) and [Table 5](#)) valid on the date of contract signed between the contracting parties shall be used, unless otherwise specified in the contract.

CHAPTER 2 TECHNICAL PROVISIONS

SECTION 1 DESIGN PRINCIPLES

1 General

1.1 Objective

1.1.1 This section states the basic principles to be considered for design and layout of drilling facilities in order to avoid hazards occurring on the installation.

1.1.2 An overall objective for the design of drilling facilities is that no single failure shall result in life threatening situations for the involved personnel, or significant damage to property and the environment.

1.2 Scope and application

1.2.1 The requirements of this section apply to all drilling systems and equipment, which have the potential to adversely affect safety or integrity of the offshore installation.

1.2.2 The requirements apply specifically to drilling systems and equipment on board offshore installations.

1.2.3 The principles stated in this section shall be fulfilled in implementing requirements outlined elsewhere in this offshore standard.

2 Overall safety principles

2.1 General principles

2.1.1 *Drilling systems* are systems, including utilities, dedicated for the drilling operations. Drilling systems are needed in order for the drilling unit to operate as intended, i.e. functions ensuring the purpose of the drilling unit.

Guidance note:

Drilling systems includes all dedicated systems covered by this standard, except for safety systems, which are principally different in their purpose. For safety systems, see [2.1.4].

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2.1.2 Drilling systems, including all components/utilities, shall be designed to minimise risk of hazards to personnel, property and environment, by application of the following general principles:

- .1 No single failure or maloperation shall result in life threatening situations for the involved personnel, or significant damage to property and/or the environment.
- .2 All equipment shall be provided with indicating instruments which will provide the necessary information for safe operation, control, and emergency action.
- .3 Where practicable, hazards should be avoided or prevented through safe design such that further protection measures are not required.
- .4 Systems and equipment shall be protected against excessive loads, pressure, temperature and speed.
- .5 Systems and equipment shall be designed for operation throughout a specific design life. Unless otherwise specified, the design life shall be taken as 20 years.

2.1.3 A *safety function* is a function which is provided to prevent, detect/warn of an accidental event/abnormal condition and/or mitigate its effects.

2.1.4 A *safety system* is generally defined as a system, including required utilities, which are provided to prevent, detect/warn of an accidental event/abnormal conditions and/or mitigate its effects.

Guidance note:

- 1) A safety system is a system that only performs safety functions.
- 2) Examples of safety systems related to drilling (other safety systems are given in DNVGL-OS-A101):

- PSD for well test
- BOP/Diverter/Choke and Kill incl. control system
- Safety logic unit for MPD
- Other safety systems for drilling systems/equipment (e.g. emergency stop, overload protection, etc.).

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2.1.5 Safety systems, including all components/utilities, shall be designed by application of the following general principles:

- 1 Safety systems shall be provided in order to perform safety functions on occurrence of predefined abnormal states/failures. Safety systems shall include all resources required to execute the safety functions.
- 2 Safety systems shall be independent of drilling systems, thus making safety functions separate and independent of drilling control functions. Effectively, a failure in the control function shall not have any impact on the safety function.
- 3 Safety systems shall bring the drilling systems/processes into predefined *safe states* if loss of control occurs. Safe states shall be defined for all relevant operational modes.
- 4 Safety systems shall have R0 availability in accordance with [Table 3](#), or be fail-safe.
- 5 Special considerations to be made where fault conditions may develop too fast to be counteracted by local manual intervention.
- 6 Safety systems related to drilling shall also comply with relevant requirements for such systems in reference standards listed in [Ch.1 Sec.1 Table 5](#) (e.g. DNVGL-OS-A101 and DNVGL-OS-D202).
- 7 Requirements for other safety systems, such as ESD and F&G, shall be according to the respective DNV GL standards, e.g. DNVGL-OS-A101 and DNVGL-OS-D301. For production/well testing plant, shutdown, and blowdown systems see DNVGL-OS-E201.

Guidance note 1:

Safety functions covered by this standard do not necessarily need to be incorporated into one common safety system.

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Guidance note 2:

While safety systems (safety functions) as a principle are independent of drilling systems (control functions), it might be accepted that some safety functions are performed or supported by the drilling system, if the overall safety level is ensured. In this scenario it is of essence to avoid common cause failures.

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2.2 Well barriers

2.2.1 A *well barrier* is an envelope of one or several dependent well barrier elements preventing a well incident.

Two independent and tested well barriers are required during operation:

- primary well barrier
- secondary well barrier.

Guidance note:

See definitions of well barrier and well barrier element in [Ch.1 Sec.1 \[2.2\]](#).

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2.2.2 Each well barrier involves one or several well barrier elements that shall be tested and verified by defined and appropriate methods.

2.2.3 The well barrier/well barrier element shall as a minimum be designed, selected and constructed such that:

- it can withstand the maximum rated differential pressure
- it can be leak tested and function tested or verified by other methods
- it can operate competently and withstand the environment for which it may be exposed to over its life time

- it is safe to maintain or replace well barrier elements
- re-establishment of a lost well barrier, or establishment of another temporary well barrier can be done
- it's physical location and integrity status is known at all times when such monitoring is possible.

2.2.4 A well barrier element of the primary well barrier shall be independent of the secondary well barrier and vice versa. Otherwise, an exception has to be justified by risk reducing measures applied to reduce the risk as low as reasonable practicable.

2.2.5 Well barrier elements covered by this standard shall be identified and documented to be in compliance with requirements for safety systems/essential functions, as defined in [Sec.5](#).

Guidance note:

The scope of this standard does not cover all barrier elements.

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2.2.6 The primary well barrier consists as a minimum of the mud column in the well, and is ensured if the hydraulic pressure in the wellbore at all times overbalances the exposed formation pore pressure.

Guidance note 1:

The wellbore pressure should not unintentionally exceed exposed formation fracture pressure.

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Guidance note 2:

For MPD the primary well barrier might also consist of additional equipment of the MPD pressure control system as explained in [Sec.5 \[8\]](#).

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2.2.7 The secondary well barrier consists of an envelope of several dependent well barrier elements, e.g. BOP, wellhead, casing/liner, casing cement, packers, etc.

2.3 Drilling systems and equipment

2.3.1 Drilling systems can perform essential, important or non-important functions.

2.3.2 An *essential function* is generally defined as a function whose loss or failure could create an immediate danger to personnel, environment or the installation.

2.3.3 Essential functions shall have R0 availability in accordance with [Table 3](#).

2.3.4 Essential functions shall normally include two independent levels of protection to minimise the adverse effects of a single fault in equipment, associated system and controls. In order to reduce the probability for common cause failures, the two levels of protection shall be provided by functionally different types of devices; ensuring uncompromising reliability at all times.

Guidance note:

The requirement for two levels of protection may be disregarded if the function availability requirement in [\[2.3.3\]](#) can be documented otherwise.

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2.3.5 Requirements to an essential function are applicable to all systems/equipment providing that respective function.

Guidance note:

With "systems/equipment providing a function" it is meant all systems/equipment necessary to ensure that the respective function is available (in accordance with the availability requirement for that function). This will include dedicated equipment as well as control systems and utilities, e.g. hydraulic or electrical supply (as relevant).

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2.3.6 An *important function* is generally defined as a function which does not necessarily need to be continuously available, as even though a failure or non-availability of the function could impair the safety of personnel, environment or the installation, it would not create an immediate danger.

2.3.7 Requirements to an important function are applicable to all systems/equipment providing that respective function.

Guidance note:

With "systems/equipment providing a function" it is meant all systems/equipment necessary to ensure that the respective function is available (in accordance with the availability requirement for that function). This will include dedicated equipment as well as control systems and utilities, e.g. hydraulic or electrical supply (as relevant).

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2.3.8 A *non-important function* is defined as a function which is neither essential, nor important.

2.3.9 Various operational modes are relevant for a drilling installation (operation, waiting on weather, survival and transit). Table 1 is considering the *operation* mode. The intention is to identify which main systems covered by this standard are safety systems, and which are drilling systems. For the drilling systems, it further identifies if a specific function is essential, important or non-important.

Table 1 Safety system and function categorisation

<i>Systems and functions for the operation mode</i>	<i>Drilling</i>	<i>Fixed to bottom operations (e.g.: Well testing)</i>
Well control systems (with the exception of riser systems)	S	S
Riser systems, including tensioning system	E*	E
Heave compensation	E*	E
Hoisting	E*	I
Rotation	I	N
BOP, pipe and riser handling	I	N
Drilling fluid mixing, transfer and circulation, including cementing	I	I
Well testing	N	E*
Blowdown system for well testing	-	S
MPD pressure control system	E*	E*
Safety logic unit for MPD	S	S
S = Safety system, E = Essential function, I = Important function, N = Non-important function * All functions might not be considered as essential. See Sec.5 for details.		

Guidance note:

In addition to the safety systems mentioned in [Table 1](#), drilling systems/equipment will also have separate safety systems as part of the system/equipment package, e.g. emergency stops/overload protection. See [Sec.5](#) for further details.

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2.3.10 To facilitate understanding of these overall safety principles, prescriptive requirements for systems and equipment are given in [Sec.5](#). However, if a system or equipment other than those mentioned in [Sec.5](#) is used, which can be defined as providing an essential/important or safety function according to [\[2.1.3\]](#), [\[2.3.2\]](#) and [\[2.3.6\]](#), then the system or equipment shall comply with the safety principles applicable for respective functions.

3 Arrangement and layout

3.1 General arrangement

3.1.1 Arrangement and layout of the drilling plant and its systems and equipment shall be arranged as far as possible in agreement with the principles of DNVGL-OS-A101 in order to ensure safe operation.

3.1.2 Equipment and areas with high risk potential shall be segregated from those with a low risk potential, (see DNVGL-OS-A101, Ch.2 Sec.2).

3.1.3 All equipment and parts, which shall be operated, inspected, or maintained on board shall be installed and arranged for safe and easy access.

3.1.4 Facilities for safe isolation shall be provided for all parts of the drilling and utility systems, which contain high pressure fluids, flammable or toxic substances, and which require to be accessed for maintenance or other operations while adjacent parts of the system are energised or pressurised.

3.1.5 Location and design of critical equipment and facilities shall include due consideration of potential for dropped objects, especially in connection with materials and equipment handling.

3.1.6 Equipment with moving parts or hot or cold surfaces, and which could cause injury to personnel on contact, shall be shielded or protected.

Guidance note:

Shielding or insulation should normally be installed on surfaces, which can be reached from work areas, walkways, stairs or ladders if surface temperatures exceed 70°C.

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3.1.7 If geographical location of operation is such that ice and snow accumulation may occur, systems or equipment for effective de-icing with necessary availability shall be installed.

3.1.8 Decks and work areas shall include efficient drainage for spillage of water, oil, drilling mud, etc., which could occur. Hazardous drains from drill floor, substructure and well test area shall be collected and routed to a dedicated slop tank system, and shall be segregated from drains from non-hazardous areas.

3.1.9 The driller shall have a clear view of all activities at the drill floor and within the derrick (or similar) during operation.

Guidance note:

The clear view should be provided directly by a suitable location of the control cabin or indirectly by e.g. use of monitors (cameras).

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3.2 Arrangement of safety systems

3.2.1 Safety systems which may be required to operate simultaneously during a defined accidental event shall be controlled from the same physical location to the extent possible. Alternatively, efficient and fool-proof visual and/or audible communication facilities shall be provided to enable safe operation of the drilling plant and installation.

3.2.2 Safety systems and relevant controls shall be located, or otherwise protected, so as to remain operational and safely accessible for the necessary time during an uncontrolled well situation or other defined accidental event, (see DNVGL-OS-A101 Ch.2 Sec.2).

3.2.3 In particular, the main control unit of such systems, including the following, shall not be located on the drill floor:

- BOP or diverter control system
- necessary provisions for cutting of drillpipe at any time
- disconnection (subsea BOPs only).

Guidance note:

Necessary provisions for cutting of drillpipe may be super shear ram (cuts tool joint), 2 shear rams or possibility of emergency lowering or hoisting.

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3.2.4 Control hoses, cables, and other means necessary for operation of safety systems shall be suitably located or protected so as to ensure availability of such systems for the time required during the defined accidental events.

3.2.5 Back-up supplies to systems important for safety shall be provided to enable safety systems to remain available for the time required during the defined accidental events. Electrical equipment required to remain operational in areas affected by a gas release (e.g. well control system) shall be certified for hazardous area zone 2, (see also DNVGL-OS-A101 Ch.2 Sec.3.)

3.2.6 All alarms initiated by the control and monitoring systems and the safety systems shall be released and acknowledged in the driller's cabin, toolpusher's office and the central control room, as appropriate for the safe operation of the drilling plant and the unit. The station in command shall be clearly indicated.

3.2.7 When an emerging (stick out) device for overriding a safety action is provided, it shall be arranged such that unintentional operation is prevented. There should be clear indication when the device is

operated.

3.3 Escape and access routes

3.3.1 See DNVGL-OS-A101, Ch.2 Sec.5 for general requirements for escape and escape routes, as well as specific requirements for stairs, ladders, handrails, etc.

4 Fire and explosion

4.1 Active and passive fire protection

See DNVGL-OS-D301 for basic fire protection requirements.

4.2 Hazardous areas

See DNVGL-OS-A101. This reference also contains specific requirements for drilling units.

4.3 Ventilation

See DNVGL-OS-A101 Ch.2 Sec.3.

4.4 Fire and gas detection

See DNVGL-OS-D301 Ch.2 Sec.5.

5 Automation and monitoring, safety configuration

5.1 General

5.1.1 As far as possible, the systems shall be arranged so that no single failure or maloperation shall result in life threatening situations for the involved personnel, or significant damage to property and/or the environment.

5.1.2 Layout design of human-machine interface devices shall include due consideration of the user interface, and with attention to the significance of human factors during an emergency situation. Graphical information systems shall contain all relevant functions for safe operation, shall be easy to understand and operate, and shall enable system overview.

5.1.3 For systems serving essential/important functions and for safety systems, deviations between a command action and expected result of the command action shall initiate an alarm.

5.1.4 When two or more safety actions are released by one failure condition (e.g. start of standby pump and stop of engine at low lubricating oil pressure), these actions shall be activated at different levels. The least drastic action shall be activated first.

5.2 Field instrumentation

5.2.1 The field instrumentation belonging to separate essential process segments shall be mutually independent.

Guidance note:

System B is independent of system A when single system failures occurring in system A have no effect on the maintained operation of system B. (However, single system failure occurring in system B may/may not affect the operation of system A.)

Two systems are mutually independent when a single system failure occurring in either of the systems has no consequences for the maintained operation of the other system according to the situation described above.

Redundancy may provide the necessary independence. See [5.4].

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5.2.2 When the field instrumentation of a process segment is common for several systems, and any of these systems is providing an essential function, failure in any of these systems shall not affect this field instrumentation and vice versa.

5.2.3 Where manual emergency operation of an essential process segment may be required, the necessary field instrumentation shall be independent of other parts of any system.

5.2.4 Electronic components, which replace traditional mechanical components, shall have the same reliability as the mechanical component being replaced.

5.2.5 The fail-safe principles described in [5.2.6] shall be applied to all systems, regardless of energy transfer principles.

Guidance note:

Energy transfer principles may be e.g. electrical, hydraulic or pneumatic.

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5.2.6 As an example, the output circuits from safety functions in systems given in Table 1 shall be configured as per the principles given in Table 2.

Table 2 Safest conditions and corresponding output circuit configuration

System	Safest condition in case of failure to the system		Output circuit configuration ²⁾
	Drilling	Fixed to bottom operations (e.g. well testing)	
Well control system	Operational	Operational ¹⁾	NDE / NDE
Emergency mixing and circulation of drilling fluid	Operational ³⁾	N/A	NDE / -
Main hoisting systems	Shutdown ⁴⁾	Shutdown ⁴⁾	NE / NE
Heave compensation	Operational ⁶⁾	Operational ⁶⁾	NDE / NDE
Integrated main hoisting and heave compensation systems	Operational ⁵⁾	Operational ⁵⁾	NDE / NDE
MPD pressure control system	* 7)	* 7)	*7)/(*7)
Well testing facilities (blowdown systems)	N/A	Operational	- / NDE
Well testing facilities (excluding/blowdown systems)	N/A	Shutdown	- / NE

Notes:

1) See well control systems as applicable for well testing. (Last two items of this table.)

2) See DNVGL-OS-A101 Ch.2 Sec.4 for definitions and general requirements.

3) See Sec.5 [7.1.2] for details.

4) See Sec.5 [5.2.3] for details.

5) See Sec.5 [4.1.2] for details.

6) See Sec.5 [5.2] for details.

7) See Sec.5 [8] for details.

NDE = Normally de-energised, NE = Normally energised

5.3 Integrated system

5.3.1 User Input Devices (UIDs) for control shall be available only on workstations from where control is permitted.

5.3.2 Multifunction of Visual Display Units (VDU) and User Input Devices (UID) shall be redundant and interchangeable. The number of units at control stations shall be sufficient to ensure that all functions can be provided with any one unit out of operation, taking into account any functions which are required to be continuously available.

5.4 Redundancy

5.4.1 Redundant systems shall be installed to the extent necessary to maintain the safe operation of the installation. Switchover to redundant systems shall be simple, and shall be available in event of failure in the control and/or monitoring systems.

Guidance note:

Redundancy means that any of two or more *mutually independent* systems (see [5.2.1]) can maintain a function. The two systems may be of different type or have different functionality.

The selection of spare parts, redundancy, or manual operation facilities, in order to ensure continuity of operation upon failure of instrumentation equipment should include due consideration of the manning level.

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5.4.2 Automatic switching between two systems shall not be dependent on only one of the systems.

5.5 Power supplies

5.5.1 Systems that are critical to the safety of personnel and the installation shall be powered as required by DNVGL-OS-D201, Ch.2 Sec.2 including a transitional source of power/UPS.

Guidance note:

The time required to operate the system on UPS is an essential factor when designing the system, and will depend on the duration of availability of input power (main or emergency).

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5.5.2 The UPS shall be monitored with alarm for failure from a manned control room.

Guidance note:

The following failures should normally be considered:

- loss of input power
- internal UPS failure.

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5.5.3 The emergency power systems and UPS and associated controls, etc. shall be self contained, and located such that they are not vulnerable to events which may affect the main power supply.

6 Response to failures

6.1 Failure detection

6.1.1 Safety systems and systems for essential and important functions shall have facilities to detect the most probable failures that can cause erroneous or reduced system performance ("self-check" facilities), or which could affect the integrity and safety of the equipment or the offshore installation.

6.1.2 The self-check facilities shall cover, as a minimum, the following failure types:

- power failures
- sensor and actuator failures
- loop failures (at least broken connections and short circuit) for normally de-energised (normally open) circuits in safety systems.

And additionally for computer based systems:

- communication errors
- computer hardware failures
- software execution failures
- software logic failures.

6.1.3 Adequate failure detection may be obtained by combining two mutually independent systems, which together provide the required failure detection properties, e.g. an automatic control system together with an independent alarm system.

6.1.4 Detection of failures in systems other than non-important systems shall initiate an alarm.

6.2 Fail-to-safety

The most probable failures, e.g. loss of power or cable or wire failures shall result in the least critical of any possible new conditions.

This shall include consideration of the safety of the systems themselves, as well as the safety of the offshore installation. See [Table 2](#) for examples.

7 System and function availability

7.1 General

7.1.1 The time needed to bring a system/function back in operation upon a failure condition shall be adapted to the availability requirements imposed on the system/function served.

7.1.2 Typical maximum unavailable times for the different categories are found in [Table 3](#).

Table 3 Maximum unavailable time

Category	Time
Continuous availability (R0)	None
High availability (R1)	45 s
Manual system restoration (R2)	10 minutes
Repairable systems (R3)	3 hours

7.2 Continuous availability (R0)

7.2.1 A function that shall be continuously available shall be designed such that there is no interruption of the functionality during normal operation modes or in case of a single failure.

7.2.2 Changeover between redundant systems shall take place automatically and with no disturbance of the continuous operation of the function in case of system failure. User requested changeovers shall be simple, easily initiated, and shall take place with no unavailable time for the function.

7.2.3 User interfaces of redundant systems shall allow supervision of both systems from the same position.

7.2.4 As a principle, all safety functions (systems) and essential functions should belong to this category unless it is demonstrated that it is possible to suspend these specific operations without compromising the safety of the personnel, equipment or installation (see [Table 1](#)).

7.3 High availability (R1)

7.3.1 A function that shall have high availability is to be designed to provide continuous availability in normal operation modes.

7.3.2 In case of failures, changeover between redundant systems shall take place automatically, if such redundancy is required. User requested changeover in normal operation shall be simple, easily initiated, and shall take place within the same maximum time.

7.3.3 User interfaces of redundant systems shall be located close to each other and changeover between the systems shall have no significant effect on the user's maintained execution of other tasks.

7.4 Manual system restoration (R2)

A function that requires manual restoration shall be designed to provide restoration of the function within a maximum time specified for R2, in case of failures.

Guidance note:

Restoring a function may involve a limited number of simple manual actions.

User interfaces of redundant systems may be designed for manning of normally unattended workstations when required, provided such manning is immediately available.

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7.5 Repairable systems (R3)

A function of category R3 shall be designed to provide restoration of the function within a maximum time specified for R3 in case of failures.

Guidance note:

Restoring a function may involve a number of manual operations, including minor replacements or repair of equipment.

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8 Design load conditions

8.1 General

8.1.1 The drilling system and each part of the drilling plant shall be designed to operate safely under the maximum foreseeable load conditions experienced during drilling operations, and to limit the risk of drilling hazards. Subsections [8] and [9] give further information for calculation of such loads and loading conditions.

8.1.2 All external loads, which may adversely affect the proper functionality, safety, strength and reliability of the drilling plant shall be considered.

8.2 Design pressure and temperature

8.2.1 The specified design temperature and pressure conditions for equipment and components shall include adequate margins to cover uncertainties in the prediction of internal and external temperature or pressure conditions.

8.2.2 The design pressure shall normally include a margin above the maximum operating pressure.

8.2.3 The design conditions shall include start-up, shutdown, and abnormal conditions which are considered as reasonably likely to occur.

8.2.4 Where necessary, analysis shall be used to establish operational limitations, which are not readily or reliably available.

Guidance note:

E.g. low temperature in choke and well testing systems, etc.

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8.3 Environmental loads

8.3.1 The environmental criteria and motion characteristics used for the design of the unit during applicable operating and non-operating conditions shall be used.

Guidance note:

Normally, the following design conditions should be evaluated:

- operation
- waiting on weather (applicable for floating installations only)
- transit
- survival
- accidental heel.

See DNVGL-OS-C101 for further guidance.

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8.3.2 Design of the system shall include allowance for relative motion between different parts of the system, to the extent necessary to avoid inducing detrimental stresses (e.g. for design of riser systems).

8.3.3 Tests to confirm component or system suitability for intended purpose shall be performed and documented, as necessary.

8.3.4 Where applicable, the following aspects shall be taken into consideration when establishing the environmental loads:

- motion of the unit (i.e. heave, roll, pitch, sway, surge and yaw)
- wind loads
- air temperatures and humidity
- loads from possible accumulation of snow and ice
- earthquakes (fixed installations only).

8.3.5 Motion

- .1 Unit motion due to wind, current, and wave loads shall be included in the design loads for all major structural components of importance to drilling facilities, e.g. pipe handling equipment, BOP handling cranes, derrick structure, etc.
- .2 Unit motion shall also be considered when evaluating fixture of pressure containing equipment having considerable mass, such as air pressure vessels, etc.
- .3 The unit motion due to surge, sway and yaw are normally relatively small. This motion may be neglected provided that the greater of the conservative value combinations (8.3.5 .4) are considered for the actual location, and for all relevant modes (i.e. transit, operational and non-operational modes).
- .4 *Value combinations*
 - maximum heave and maximum pitch
 - maximum heave and maximum roll
 - maximum heave and square root of sum of squares maximum roll and maximum pitch, i.e.

$$Heave_{max} + \sqrt{(Roll_{max})^2 + (Pitch_{max})^2}$$

- .5 Where more accurate motion analysis forms the basis for design motion loads, such analysis should also take into account the effect of surge, sway and yaw accelerations.
- .6 Maximum limiting values for transit and operational mode shall be documented, defined either as horizontal and vertical accelerations respective to g (a_x , a_y and a_z), or as roll, pitch and heave amplitudes and periods, together with distance to roll or pitch centre.

Guidance note:

Where vessel motion characteristic is not available, conservative maximum pitch and roll accelerations of 0.35 g (at drill floor level, should be proportionally adjusted upward at higher levels) should be considered together with maximum heave acceleration of 1.3 g for non-operational mode (survival).

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8.3.6 Wind loads

- .1 Wind loading of exposed equipment and components for all relevant modes shall be included as a design load in the design calculations. Limiting maximum occurring wind speeds during transit and operation shall be clearly defined (specifying reference height above sea level and average time period).

Guidance note:

For details of calculation of wind loads associated with various. wind speeds and geometry, see e.g. DNV-RP-C205.

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- .2 Unless otherwise specified, 100-year storm values for the intended geographical location shall be used for evaluation of survival condition.

Guidance note:

For typical wind speeds ref. DNVGL-OS-E301 Ch.2 Sec.1 [2.3] Wind.

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8.3.7 Air temperature

Unless otherwise specified in references in [Ch.1 Sec.1 Table 1](#) and [Table 5](#), systems and equipment shall be designed for operation under ambient air temperature:

- between the minimum design temperature and 45°C
- inside machinery housing or other compartments containing equipment between 5°C and 55°C.

8.3.8 Accumulation of ice and snow

Where such weather conditions are known to occur, maximum loads from snow and ice accumulation shall be clearly defined for all relevant modes. Where location specific loading is not available, values as specified in DNVGL-OS-C101 may be used.

8.3.9 Earthquake loads

See DNVGL-OS-C101.

8.4 Operational loads

8.4.1 Principal loads

The principal loads to be considered are:

- loads due to the deadweight of the components. (If the deadweight of equipment varies with operational mode, e.g. dry weight during transit and full weight during operation, this shall be clearly specified)
- loads due to the working load (e.g. hook-load, rotary load, riser tensioner load)
- loads due to pre-stressing (i.e. loads imposed on structural items due to pre-stressing of bolts, wire ropes, etc.).

8.4.2 Vertical loads due to operational motions

- .1 The vertical loads due to operational motions shall be taken into account by multiplying the working load by a dynamic coefficient ψ .
- .2 Minimum values of ψ to be used in design calculations for specific equipment are found under respective sections of this standard.
- .3 For equipment with no specific value listed in this standard, the magnitude of ψ shall be in accordance with a recognised code or standard, as applicable.
- .4 Lower values than stated in .2, .3 above may only be applied where thoroughly demonstrated through testing, i.e. measurements of ψ during operation of the equipment under consideration.

Guidance note:

Also loads due to tension system hysteresis, eigen-frequency and dynamic amplification of motions in BOP, riser, tension cylinders are to be considered where relevant.

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8.4.3 Horizontal loads due to operational motions

Where applicable, examples of relevant loads to be considered are:

- inertia forces due to horizontal movements
- centrifugal forces
- forces transverse to rail resulting from reeling and skew motion
- buffer loads, etc.
- For further details on calculation of these loads, see *DNV Standard for Certification No. 2.22 Lifting Appliances*.

8.4.4 Well fluid composition and specific weight

- .1 Design shall include due consideration of well fluid composition, with regard to such phenomena as corrosion, stress corrosion cracking, erosion, fouling, etc.
- .2 Unless otherwise specified, a specific drilling fluid weight of 2.1 t/m³ shall be used as design basis for relevant equipment (e.g. mud tanks, riser tensioner etc.).

8.4.5 Accidental loads

- .1 Unless otherwise identified (e.g. from safety assessment or shelf-state requirements), the accidental loads given in .2 to .4 shall apply.
- .2 The drill floor shall be designed to withstand the impact from a falling 9 1/2" drillcollar stand from a height of 1.5 m.
- .3 For floating installations, all equipment with potential to impair access or escape on the unit shall be capable to withstand an emergency static condition with the unit inclined at an accidental heel angle. The heel angle shall correspond to a two compartment damage (static), together with the dynamic

motion response resulting from a one year return period in the damaged position. This also applies to equipment that has a potential of seriously escalating the damage situation.

Guidance note:

If the two compartment damage angle is not known, an angle of 17 ° should be applied. The dynamic motion response should be calculated based on the unit in damaged position. If these unit characteristics are not known, an additional static angle of 10 ° should be used.

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- .4 Unless means for emergency lowering of loads are provided, maximum operating weights shall be applied for this maximum inclination. The effect of other environmental loads (e.g. wind loads) need not be considered during this emergency condition.

8.5 Loading combinations

Unless otherwise specified, equipment shall be evaluated for applicable loading combinations for the following operating and non-operating conditions:

- operational
- waiting on weather (applicable for floating installations only)
- survival
- transit
- accidental heel.

9 Design calculations

9.1 General

For each loading condition, and for each item to be considered, the most unfavourable combination, position, and direction of loads which may act simultaneously shall be used in the analysis.

9.2 Design safety factors

9.2.1 Appropriate safety factors shall be applied in determination of an acceptable stress level for the different load conditions.

9.2.2 Safety factors shall be in accordance with a relevant recognised code, standard, or recommended practice for each particular component, unless otherwise specified in this standard.

Guidance note:

E.g. *DNV Standard for Certification No. 2.22 Lifting Appliances* for mechanical components, unless covered by applied code or standard.

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9.2.3 The yield strength used in calculations shall not exceed 0.85 of the specified minimum tensile strength.

9.3 Modes of failure

9.3.1 The mechanical components of the drilling system shall be designed against the following possible modes of failure, including, where relevant:

- excessive yielding
- structural stability
- fatigue fracture.

9.3.2 *Excessive yielding*

The stress analysis shall normally be based on the elastic theory. An ultimate strength (plastic) analysis may be used where appropriate.

9.3.3 *Structural stability*

The stability analysis shall be carried out according to generally accepted theories.

9.3.4 *Fatigue*

- .1 Areas of mechanical components that are susceptible to fatigue damage shall be evaluated.
- .2 Structures with slender members that are exposed to direct wind loading shall be documented as able to withstand possible wind induced oscillations.
- .3 The fatigue analysis shall be based on a period of time equal to the planned life of the drilling plant. Unless otherwise specified, a 20 year design life shall be applied.
- .4 The fatigue analysis shall be based on a representative load spectrum for the occurring loads.

Guidance note:

If detailed inertia load spectrum is not available, a Weibull parameter h of 1.1 can be used, together with extreme inertia loads corresponding to the design life of the drilling plant. If this approach is used, the effect of directional spreading of the environmental loads should not be used in the fatigue analysis.

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SECTION 2 MATERIALS AND WELDING

1 General

1.1 Principles

1.1.1 Materials selected shall be suitable for the purpose, and shall have adequate properties of strength, notch toughness, and ductility. In addition, materials to be welded shall have good weldability properties.

1.1.2 Materials to be used for applications involving H₂S-containing fluids (sour service) shall be selected according to NACE MR0175/ISO 15156 and any additional requirements under this standard.

1.1.3 The materials shall generally be specified in accordance with recognised standards. Special written specifications may also be accepted where justified on a case by case basis.

1.1.4 Standards and specifications shall specify material properties and testing procedures, including NDT, as relevant. Requirements given in this section apply.

2 Specific requirements

2.1 General

2.1.1 For welded C-Mn steels for major pressure containing and load carrying parts the chemical composition is normally to be limited to the following carbon (C)- and carbon equivalent (CE)-values:

$$C \leq 0.22$$

$$CE = C + \frac{Mn}{6} + 0.04C \leq 0.45$$

2.1.2 When the relevant elements are known, the following carbon equivalent formula shall be used:

$$CE_{(b)} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15} \leq 0.45$$

Materials not meeting this limitation may be used provided that suitable welding procedures are applied.

Guidance note:

The welding of such materials normally requires more stringent fabrication procedures regarding selection of consumables, preheating, post weld heat treatment and NDT. See [Sec.6 \[3.1.7\]](#).

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2.1.3 Materials for structural and mechanical components shall be manufactured from materials having minimum longitudinal impact toughness according to [Table 1](#). If only transverse values are available, 2/3 of the values of [Table 1](#) apply. The requirements shall be met as an average of 3 specimens, and with no individual value to be less than 2/3 of the specified minimum average.

Table 1 Average minimum Charpy V-notch energy absorption

Yield strength (MPa)	Charpy V-notch energy (J)
Yield strength ≤ 270	27
270 < Yield strength < 420	10% of yield strength ¹⁾
Yield strength ≥ 420	42
1) Rolled structural steel delivered in normalised condition may be accepted with a minimum Charpy V-notch value of 27 J at –20°C (for a MDT = –20°C) provided that the materials are delivered in accordance with internationally recognised standards such as DIN, BS, ASTM etc. and are suitable for their intended application.	

2.1.4

1) Materials for piping and pressure retaining components are required to have documented Charpy impact values of minimum 27 J, independent of material thickness and MDT, if part of one of the following high pressure piping systems:

- choke and kill system
- high pressure mud system
- well test system
- cement system.

Guidance note 1:

Recognised piping standards such as ANSI/ASME B31.3 is considered not to fully cover the high pressure systems listed above due to special design conditions normally not present in standard process piping, e.g. water hammering effects and choking (Joule Thompson) effects. For such conditions, proper impact properties are considered important.

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Guidance note 2:

For equipment in other pressure systems, Charpy impact testing should be carried out (if applicable) in accordance with the recognized code or standard.

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2) For drilling and workover risers the Charpy impact value requirement specified in [2.1.3] shall apply.

2.1.5 Impact testing is normally required for steel materials with reference thickness above 6 mm if the Minimum Design Temperature (MDT) is below 0°C. Testing shall be carried out at or below MDT for materials under this category.

2.1.6 Where required, ref [2.7.2], bolt material documented Charpy impact properties shall be consistent with the system where the bolts are applied, see [2.1.4] if applied for piping and pressure retaining bolt assemblies and [2.1.3] if applied for structural and mechanical bolt assemblies.

2.1.7 Where standard test specimens cannot be made, subsize specimens may be used with the energy conversion factors as given in Table 2.

Table 2 Average Charpy V-notch energy absorption

<i>Specimen section (mm²)</i>	<i>Energy factor</i>
10 × 10	1
10 × 7.5	5/6
10 × 5	2/3

2.1.8 For austenitic stainless steels, impact tests are only required for design temperatures below –105°C.

2.1.9 Impact test specimens shall be sampled from a location:

- 2 mm below the surface for thickness ≤ 50 mm, or
- t/4 for thickness > 50 mm.

Guidance note:

Alternative test sample locations may be accepted on a case-by-case basis.

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2.1.10 Materials for “sour service” shall meet the hardness requirements in NACE MR0175/ISO 15156. Any welding or other fabrication affecting hardness shall be carried out according to a qualified procedure, in order to ensure that the maximum specified hardness is not exceeded.

2.1.11 Plates that transfer significant loads in the thickness direction (Z-direction) shall be guaranteed with through thickness ductility in order to reduce the probability of lamellar tearing. The minimum reduction of area, Z_z, shall not be less than 25%.

Guidance note:

Significantly loads may typically be found in:

- all cross joints with near equal plate thicknesses, or where the fillet welded plates are thicker than the continuous plate

- all T-joints, but here with leaner interpretation of the limits
- all T- and cross joints with a nominal load in z-direction exceeding 100 MPa.

Particular attention where full-pen welds are used.

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2.2 Rolled steel

The material standard or specification shall define an extent of testing comparable to that described in DNVGL-OS-B101.

2.3 Steel piping

2.3.1 Electric resistance welded pipes shall not be used for working pressure above 32 bar, or design temperatures above 300°C.

2.3.2 The material standard or specification shall define an extent of testing comparable to that described in DNVGL-OS-B101.

2.4 Steel forgings and castings

2.4.1 Testing of mechanical properties of forgings and castings shall normally be performed on a trepanned outlet or a prolongation removed from the forging or casting after completion of final heat treatment, or by random selection of forgings or castings from the same heat and heat treatment batch. The test material shall represent the thickest section of the component.

2.4.2 Separate test coupons may be accepted where justified. The separate test coupons for determining mechanical properties shall represent the actual component in every respect. The samples shall be from the same heat as this actual component, and shall have received the same forging ratio and heat treatment simultaneously with the material they represent. The test samples shall be of a dimension reflecting the critical wall thickness in the actual component.

2.4.3 Test specimens shall be as follows:

- The mechanical test specimens shall be removed from the test material at a depth of 1/4 thickness (t). When applicable, the specimens shall be located t/4 from the inner surface.
- Transverse test specimens shall normally be used.
- Minimum one full set of mechanical tests per lot shall be tested. (One lot consists of components from the same heat and the same heat treatment batch.) If components of different dimensions are in the same lot, it is sufficient to test the largest dimensions only, provided the strength requirement is the same for all dimensions.

2.4.4 Flanges, valve bodies, etc., shall normally be forged to shape, or cast. If such components are machined from forged bar stock, rolled bar stock, forged plate, or rolled plate, the material shall be tested in the transverse direction and shall meet the requirements for longitudinal specimens of forged to shape components. If using plate, testing shall also be performed in the short-transverse (through thickness) direction.

2.4.5 The material standard or specification has to define an extent of testing comparable to that described in DNVGL-OS-B101.

2.5 Cast iron

2.5.1 Cast iron shall not be used for critical parts with MDT below 0°C unless specifically justified and agreed between all parties.

2.5.2 For non-welded sheaves, impact testing of the material is not required. Nodular cast iron used for sheaves shall have a minimum elongation of 10% ($L_0 = 5 d$).

2.5.3 Mechanical properties of castings shall be tested in accordance with the requirements given in [2.4.1] to [2.4.3].

2.5.4 The material standard or specification shall define an extent of testing comparable to that described in DNVGL-OS-B101.

2.6 Other metallic material

Aluminium, copper, and other non-ferrous alloys shall have a supply condition, chemical composition, mechanical properties, weldability, and soundness according to material standard provided the requirements of DNVGL-OS-B101 are fulfilled.

2.7 Bolting material

2.7.1 In general bolt assemblies considered to be essential for structural and operational safety shall conform to a recognised standard.

Guidance note:

E.g. ISO 898-1 with regard to property class.

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2.7.2 Bolting material used in structural and mechanical bolted connections shall be consistent with the systems where the connections are applied.

Consideration shall be given to:

- nature of external loading
- design / capacity of bolted connection
- load in bolt(s)
- consequence of failure.

See [Table 3](#) for guidance.

2.7.3 Magnetic particle testing shall be carried out at least 48 hours after completion of quenching and tempering for bolts in category B (see [Table 3](#)) with yield strength above 355 N/mm². Inspection shall be in accordance with ASTM E 709.

Depth of longitudinal discontinuities shall not exceed 0.03 of the nominal diameter. Transverse cracks will not be acceptable irrespective of crack depth and location. Other surface irregularities will be considered in each case.

2.7.4 Fasteners (bolts, nuts and washers) in marine environment shall normally be hot-dipped galvanized or sherardized with coating thickness min. 50 micrometer. If special thread profiles or narrow tolerances prohibit such coating thickness, bolts/nuts may be supplied electro-plated or black provided properly coated/painted after installation. Pickling and electroplating operations shall be followed by immediate hydrogen relief (degassing) treatment to eliminate embrittling effects.

2.7.5 Major pressure retaining or structural bolts, and nuts with minimum yield strength above 490 N/mm², shall be manufactured of low alloy or alloyed steel, and shall be supplied in quenched and tempered condition.

2.7.6 For general service when the installation is in an atmospheric environment, the specified tensile properties shall not exceed ISO 898-1 property class 10.9.

Guidance note:

Property class 12.9 may only be applied if requirements to flatness of surfaces and pretension according to recognised principles are fulfilled.

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2.7.7 For submerged installations the tensile properties shall not exceed property class 8.8 or ASTM A193 B7 or equivalent.

2.7.8 For bolted joints, in which the bolts are directly exposed to the sour environment (wetted), lower

tensile properties than for 8.8 class may be necessary to comply with NACE MR0175/ISO 15156.

Table 3 Certificate requirements for bolts

Cat.	Load condition ^{1) 2) 3)}	Type of certificate
A	No tension from external load. Connection relying on friction. or Tension from external load is considered secondary and small compared to the bolts capacity. Some redundancy required, e.g. no single point of failure of bolt shall cause risk of failure of the structure.	2.2 certificate
B	Non-redundant application, e.g. riser bolts, bonnet bolts, foundation bolts.	3.1 certificate
Bolts with diameter less than 16 mm shall not be used for load bearing purposes in structure considered as special and primary. Corresponding nuts are to be in accordance with a recognized standard. No impact testing is required for nuts and washers or other bolting elements mainly exposed to compressive loads. Certificates to be according to EN 10204, October 2004		
1) Bolts intended for use below – 20°C to be subject to special consideration. In general, bolts intended for temperatures below – 20°C should be of austenitic stainless steel or equivalent. Impact tests of bolts with austenitic stainless steel are normally not required. See [2.1.8]. 2) Bolts categorized as cat.B shall be stated on actual drawings/in the design approval documentation. 3) For category A bolts used for MDT -20°C a conformity statement/certificate type 2.1 will be accepted provided it confirms to ISO 898-1 latest edition ensuring that Charpy V-notch energy of 27J at -20°C is secured by the bolt manufacturing procedures. The charpy testing is not mandatory, it might be based on statistical values. DNV GL reserve the rights to require spot checks of impact toughness.		

2.8 Sealing materials

2.8.1 The materials used shall be suitable for the intended service, and shall be capable of sustaining the specified operating pressure and temperature of the particular unit or fluid.

2.8.2 Elastomeric sealing materials used in critical components should be tested in order to ensure that they are compatible with all fluids that they will be exposed to during service.

3 Corrosion

3.1 General

3.1.1 Materials shall be selected as having adequate corrosion resistance or else a corrosion protective system such as coatings, cathodic protection, or chemical treatment of corrosive fluids, may be applied as applicable.

3.1.2 The selection of materials and/or corrosion protective systems shall ensure mutual compatibility, taking into account the effect of relevant operational parameters, techniques for inspection, monitoring and maintenance, and the required design life.

3.1.3 For certain applications, a corrosion allowance (i.e. extra wall thickness to compensate for metal loss by corrosion) may be applied. This allowance may be applied either alone, or in combination with a corrosion protective coating or chemical treatment.

4 Material certificates

All materials for main load bearing and pressure containing components shall be supplied with documentation stating:

- process of manufacture and heat treatment (metallic materials)
- results for relevant properties obtained through appropriate tests carried out in accordance with recognised standards.

Guidance note:

3.1 according to EN 10204 or equivalent.

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SECTION 3 PIPING

1 Scope

Piping includes:

- pipes
- flexible piping such as expansion elements and flexible hoses
- other parts such as valves and fittings
- piping connections such as welded connections, bolted flanges, clamps, couplings, gaskets etc.
- hangers and support brackets.

2 Piping design

2.1 General

2.1.1 Piping systems used for safe operation of the unit shall normally be separate from piping systems used for drilling and well testing operations. If cross connections for drilling or well testing operations are necessary, non-return valves or other equivalent means for avoiding possible contamination of the safe system by the hazardous medium shall be fitted.

2.1.2 Piping or pressurised components not covered by ANSI/ASME B31.3, relevant API standards, referred specifications or standards herein, should be designed according to DNV-RP-D101 Sec.5.

2.1.3 Relevant factors and combinations of factors shall be taken into account for the design evaluation of possible failure modes such as, but not limited to:

- corrosion/erosion types
- vibration, hydraulic hammer
- pressure pulsations
- abnormal temperature extremes
- impact forces
- leakages
- forced movements of connected equipment and pipe supports.

Guidance note:

Further guidance for general piping design is available in ANSI/ASME B31.3 and DNV-RP-D101.

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2.1.4 Sizing of piping or tubing downstream of PSV's or other open ended piping system shall take into account expected pressure gradients during operation of the systems.

Guidance note:

One diameter nominal size larger for the downstream piping relative to the upstream piping is recommended.

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2.2 Hard piping design

2.2.1 Piping calculations shall ensure that pipes have the necessary strength (i.e. strength thickness) throughout their operational life. In addition to the stresses arising from the internal pressure, piping shall be designed to have the necessary flexibility and resistance to take additional loads as outlined in the ANSI/ASME B31.3 and DNV-RP-D101.

2.2.2 The design code for hard piping design shall be ANSI/ASME B31.3 and the API 6 and API 16 series specifications.

Guidance note:

High pressure piping is defined in Chapter IX of ANSI/ASME B31.3 to be piping with a piping class larger than ASME B16.5 CL2500 (PN420) classes. The API piping classes are all high pressure piping. Typical high pressure piping is choke and kill lines.

Ordinary piping, e.g. piping classes CL150 - CL2500, shall be designed according to Chapter II of ANSI/ASME B31.3. (Typical piping is mud transfer lines and all firewater lines).

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2.2.3 The minimum design wall thickness, t , of straight pipes and pipe bends shall for ordinary piping (piping class CL150 - CL2500) be calculated according to ANSI/ASME B31.3, Chapter II, para 304. For high pressure piping the minimum wall thickness, t , may be calculated according to ANSI/ASME B31.3, Chapter IX, para K304.

2.2.4 Allowances such as threads, corrosion, erosion and fabrication tolerances shall be added to the minimum pressure design wall thickness. Such allowances are listed in the equation for minimum wall thickness design in the respective chapters of ANSI/ASME B31.3.

- threads, see [2.2.7]
- corrosion, see [2.2.8]
- fabrication tolerances, see [2.2.9].
- erosion, see [2.2.10].

2.2.5 The selected standard catalogue wall thickness for an actual pipe size shall not be less than t_m calculated as shown below:

$$t_m = t + allowances$$

Where

t = pressure design thickness, calculated according to ANSI/ASME B31.3, para 304.1.2, equation (3a) for piping class CL150 to CL2500 and ANSI/ASME B31.3, para K304.1.2, for High Pressure Piping.

$allowances$ = corrosion + erosion + thread depths.

See [2.2.9] below for fabrication tolerances.

2.2.6 Pipe bends and pipe elbows shall have a minimum thickness, t_m , after bending calculated according to ANSI/ASME B31.3, para 304.2 for ordinary piping and para K304.2 for High Pressure Piping.

2.2.7 Allowance for threads

The calculated minimum strength thickness of piping, which shall be threaded, shall be increased by an allowance equal to thread depth, dimension h of ANSI B2.1 or equivalent shall apply. For machined surfaces or grooves where the tolerance is not specified, the tolerance shall be 0.5 mm in addition to the specified depth of cut.

2.2.8 Corrosion allowance

The corrosion allowance, c , for steel pipes shall be as specified in Table 1, and 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 \geq 10%, the corrosion allowance shall be 0.5 mm.
- c) The corrosion allowance may be reduced down 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 1 Corrosion allowance <<c>> for steel pipes

Piping service	c (mm)
Compressed air	1
Hydraulic oil	0.3
Lubricating oil	0.3
Fuel oil	1

Table 1 Corrosion allowance <<c>> for steel pipes (Continued)

Cargo oil	2
LPG	0.3
Fresh water	0.8
Sea water in general	3
Well test or hydrocarbon service	2
Mud or cement including choke and kill lines	3
1) For pipes passing through tanks, an additional allowance for external corrosion shall be considered according to the figures given 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. 4) See [2.2.10] for mud or cement piping.	

2.2.9 Fabrication tolerances

When the value of the wall fabrication tolerances are given in percentage [%], the selected catalogue pipe nominal wall thickness, T , shall satisfy the following equation:

$$T \geq t_m \times \left(\frac{100}{100 - a} \right)$$

Where

t_m = see [2.2.5]

a = percentage negative fabrication tolerance, typical
12.5% for ordinary piping.

When the value of the wall fabrication tolerances are given in millimetres, [mm], the selected catalogue pipe nominal wall thickness, T , shall satisfy the following equation:

$$T \geq t_m + MT$$

Where

MT = fabrication tolerances in millimetres

2.2.10 Erosion allowance

Where piping is likely to be exposed to erosion, an erosion allowance shall be specified to take into account likely service conditions.

Guidance note:

Unless otherwise specified, the allowance of 3 mm above covers erosion also for mud or cement piping.

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2.3 Flexible hoses

2.3.1 The locations of flexible hoses shall be clearly shown in the design documentation.

2.3.2 Flexible hoses which are suitable for the intended use may be installed in locations where hard piping is unsuitable.

Guidance note:

Documentation on fluid compatibility might be required.

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2.3.3 Flexible hoses shall be installed as accessible for inspection.

2.3.4 Means of protection shall be provided for flexible hoses used in systems where leakage of medium could result in a hazardous situation.

2.3.5 The design of flexible hoses critical to the operation of drilling activities shall be based on a relevant recognised code or standard listed in [Ch.1 Sec.1 Table 5](#)

Guidance note:

API Spec. 16C should be applied for e.g. choke and kill hoses.

API Spec 7K should be applied for e.g. mud and cement hoses.

For booster and hydraulic (conduit line) moon pool hoses, both API Spec 16C and API Spec 7K may be applied.

Unless otherwise specified, API RP 17B or either of the 2 specifications above should be applied for other critical hoses, as applicable.

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2.3.6 Flexible hoses for the riser tension system shall preferably be designed according to API RP 17B or equivalent.

2.3.7 A fire endurance test according to IMO Res. A.753(18), ISO 15540, ISO 15541, API 16D, API 16C or equivalent shall be performed for:

- Flexible hoses and non-metallic expansion joints for flammable fluids systems.
- Flexible hoses and non-metallic expansion joints for systems where the fluid provides or supports an essential or a safety function.

The flexible hose shall maintain its integrity and functional properties for the same period as required for the total piping system and components. Ref. also DNVGL-OS-D101 Ch.2 Sec.2 [2.5].

Guidance note:

Oil-based mud is considered a flammable fluid. Hydraulic supply and hydraulic control lines to the BOP are part of a safety system (safety functions), i.e. the hydraulic (conduit line) moon pool hose for instance, must qualify a fire endurance test.

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2.4 Valves and other piping parts

2.4.1 Screwed-on valve bonnets shall not be used for valves with nominal diameter exceeding 50 mm.

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

2.4.3 Indicators shall be provided to show open and closed position of valves.

2.4.4 Closing time of valves shall be selected such that detrimental stresses due to hydraulic hammering do not occur in piping.

2.4.5 Piping parts and components not covered by recognised piping codes and standards shall be designed, calculated and documented according to DNV-RP-D101 Sec.5. Application, type of medium, design pressure, temperature range, materials, and other design parameters shall be indicated. If the piping parts have a complicated configuration that makes theoretical calculations unreliable, certified prototype proof test reports may be applied to demonstrate their suitability for the intended use.

2.5 Piping connections

2.5.1 The number of detachable pipe connections shall be limited to those, which are necessary for mounting and dismantling. The piping connections shall be in accordance with the applied code or standard, or shall be otherwise demonstrated as suitable for their intended use.

2.5.2 Joints of pipes with outer diameter of 51 mm and above shall normally be made by butt-welding, flanged, or screwed union where the threads are not part of the sealing. Joints for smaller sizes, and which are not intended for corrosive fluids, may be welded or screwed and seal welded. Tapered threads and double bite or compression joints shall be justified on a case by case basis.

2.5.3 If the piping system is rated at 207 bar (3000 psi) or above, ordinary threaded (i.e. NPT) connections shall not be used for mud system, choke and kill system, cement system or well test system, or joints in other piping systems subject to bending or vibrational loads.

Guidance note:

ANSI /ASME B31.3 states that threaded joints may only be used for instrumentation, vents, drains, and similar purposes, and shall not be larger than NPS ½". Threaded joints shall not be used where subject to bending or vibrational loads, which is normally the case for mud systems, choke and kill systems, cement systems or well test systems.

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2.5.4 Weld neck flanges shall be forged to a shape as close to the final shape as possible.

2.5.5 Couplings with stud ends may only be used where suitable, and where used, shall have tapered threads.

2.5.6 Calculations of branch reinforcement are required where:

- weldolets of unrecognized type and shape are used in the branch connection, or
- the strength is not provided inherently in the components in the branch connection
- fabricated reinforced and unreinforced tees are used.

Guidance note:

See ANSI/ASME B31.3, Sec.304.3 for further details.

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2.5.7 Piping in which expansion joints or bellows are fitted shall be adequately adjusted, aligned, and clamped. Protection against mechanical damage shall be provided where necessary. See DNV-RP-D101 Sec.3.10 for further details.

2.5.8 End fittings shall be designed and fabricated according to recognised codes or standards.

3 Supporting elements

3.1 General

3.1.1 The piping system shall be mounted and supported 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
- detrimental vibrations will not arise in the system.

3.1.2 Welded supports shall not be applied to piping exposed to water hammering, vibration and rated 207 bar (3000 psi) or above.

Guidance note:

This will typically include HP-mud systems, choke and kill systems, cement systems and well test systems.

Welded support for such systems may only be applied if the following conditions are agreed upon:

- Doubler plates should be introduced between support and piping, material should meet the requirements of recognised code (e.g. ANSI B31.3) and be of at least the same quality as the support material.
- Doubler plates shall be welded on using the same parameters and conditions as specified in the welding procedure.
- Piping stress or fatigue and flexibility analysis performed according to recognised code (e.g. ANSI B31.3, Ch.IX).

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3.1.3 Where this cannot be avoided, doubler plates shall be used, or the support shall be welded to the pipe in a way that introduces the minimum of stresses to the pipe surface from forces acting on the support.

3.1.4 Gland type (stuffing box) penetrations shall be applied for pipe penetrations through decks or bulkheads.

4 Pipe stress and flexibility analysis

4.1 General

4.1.1 Pipe stress and flexibility analysis shall be performed for the following systems:

- high pressure mud and cement
- choke and kill system
- hydraulic main hoisting systems

- permanent well test piping.

The analysis shall be performed in accordance with ANSI/ASME B31.3 and DNV-RP-D101.

Guidance note:

Requirement to flexibility analyses are described in ANSI/ASME B31.3 para 319 and K319. Flexibility analysis is also covered in DNV-RP-D101 Sec.2.2.3, 3.4.6, 3.4.7 and 3.4.8.

Requirement to fatigue calculations of high pressure piping is given in ANSI/ASME B31.3, Chapter IX, para K304.8 and the following sub-sections. Additional information is given in DNV-RP-D101 Sec.3.12.

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4.1.2 All design loads as listed in DNV-RP-D101 Sec.3.4 shall be evaluated where relevant.

4.1.3 Flange stress or leakage calculations shall be performed and documented for the highest loaded flange for each pipe size and pressure class. Additional information is given in DNV-RP-D101 Sec.3.8.

SECTION 4 ELECTRICAL AND AUTOMATION/SAFETY SYSTEMS

1 Scope

This section gives requirements primarily for the following systems and equipment:

- All safety systems (as explained in [Sec.1](#) and [Sec.5](#)).
- All systems/equipment providing essential or important functions (as explained in [Sec.1](#) and [Sec.5](#)).

Systems such as ESD, F&G shall also be according to the respective standards, DNVGL-OS-A101 and DNVGL-OS-D301. For production plant shutdown and blowdown systems, see DNVGL-OS-E201 for complete requirements.

2 Electrical systems

2.1 Application

2.1.1 The requirements regarding electrical systems and components shall be as required by DNVGL-OS-D201 Electrical systems.

2.1.2 Power supply requirements to the drilling plant shall be in accordance with the principles given in [Sec.1](#) and detailed requirements for drilling systems and components as given in [Sec.5](#).

2.1.3 Other internationally recognised codes and standard such as IEEE, IEC or similar may be applied upon prior agreement in each case.

2.1.4 In case of loss of main power it shall be possible to secure the well. It shall be possible to perform the following functions on emergency power in relevant combinations:

- transfer and circulate drilling fluids (ref. [Sec.5 \[7.1.2\]](#))
- recharge BOP control system accumulators
- if the BOP has only one shear ram, not capable of shearing tool joint and sealing the well, it shall be possible to hoist and lower the main hoisting system to be able to shear the work-string (ref. [Sec.5 \[3.2.1\].4](#))
- adjust riser tension and heave compensation system.

For dynamically positioned units these requirements might not be applicable. These units shall have the emergency disconnect system operational, ref. [Sec.5 \[3.2.4\]](#).

Guidance note:

For DP units which might have several independent power systems and no dedicated emergency power, the above requirement will only be applicable for situations when the unit is capable of keeping its position, but has reduced power generation.

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2.1.5 The electrical power distribution to drilling shall at least be split into two rooms to prevent that a single point failure will result in loss of all the essential functions for drilling equipment.

Guidance note:

System that are defined as essential ref. [Sec.1 Table 1](#) should be powered from different switchboards located in separate compartments. The electrical power system and power control should also be split into at least a two split system.

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3 Automation and safety systems

3.1 Application

3.1.1 The requirements regarding instrumentation, control and monitoring systems and components shall be as required by DNVGL-OS-D202 "Automation, Safety and Telecommunication Systems".

3.1.2 Other internationally recognised codes and standards such as API, IEC may be used provided that the additional requirements of this standard are fulfilled over and above the requirements of any other

standard applied.

3.1.3 Instrumentation equipment shall be suitable for marine use, and shall be designed to operate under environmental conditions as described in DNVGL-OS-D202 Ch.2 Sec.4 [2]. A lower value may be acceptable provided that the equipment supplied is suitable for the actual operating conditions identified. All contracting parties shall agree to the revised values.

3.1.4 Radio remote controls and other wireless remote control systems shall comply with DNV Standard for Certification No 2.22 Lifting Appliances Ch.2 Sec.3, 6.4.

Alternative means of reaching similar level of safety will be handled on a case-by-case basis.

SECTION 5 DRILLING SYSTEMS AND EQUIPMENT

1 General

1.1 Objective

The requirements of this section are intended to ensure safe and effective design and use of specific items of drilling equipment and facilities.

1.2 Scope and application

1.2.1 These requirements shall be applied to all drilling facilities, where relevant to the type of equipment to be used.

1.2.2 Systems or functions for which requirements could vary depending on type of installation (fixed, floating, permanently moored, DP operated etc.) are specified under each drilling system in question. See also [Sec.1 Table 1](#).

However, the impact this will have on other non-drilling systems are not included within this standard, see other offshore discipline standards relevant for the system in question.

Guidance note:

E.g. requirements for passive or active fire protection of permanently moored installations compared to that required for DP operated vessels.

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1.3 Control and monitoring

Requirements for control and monitoring are grouped to the extent possible under each system. Systems shall also be in line with the general system requirements found in this section and general requirements for all systems and equipment in [Sec.1](#) and [Sec.4](#).

1.4 Hydraulic and pneumatic systems

1.4.1 Hydraulic or pneumatic equipment shall be fitted with safety valves. For accumulators, see DNVGL-OS-D101, Ch.2 Sec.4 [8.4.3].

1.4.2 Safety valve relief line should be one pipe size larger than upstream of safety valve.

1.4.3 Common relief line header shall be at least one pipe size larger than largest pipe upstream of corresponding safety valve.

1.4.4 *Hydraulic systems*

- .1 For design requirements for components of a hydraulic system, see [Sec.3](#). For components not covered in this section (pressure vessels etc.), see [Ch.1 Sec.1 Table 5](#).
- .2 The hydraulic fluid shall not corrode or attack chemically the components in the system. The fluid 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.
- .3 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.
- .4 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.
- .5 Air pipes from hydraulic oil circulation tanks and expansion tanks shall be lead to safe locations so that any escaping oil does not reach potential ignition sources.
- .6 Design of hydraulic systems shall ensure smooth operation of the system, and that operation will be within the design limitations (e.g. within the dynamic factor ψ , buffer loads, etc. applied).

Guidance note:

This will include e.g. dampening of end stroke of cylinders and soft characteristics of operating valves.

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- .7 Means for filtration and cooling of the fluid and for deflation of entrapped gases shall be incorporated in the system where found necessary.

Guidance note:

Where applicable, filtration of return lines is recommended to avoid possible impurities from being spread to interconnected systems.

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- .8 Systems requiring continuous operation or for which impurities may cause critical maloperation shall be provided with two filters in parallel and continuous filter status monitoring. Alarm shall be initiated for abnormal conditions.

Guidance note:

E.g. hydraulic heave compensated system during fixed bottom operations.

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- .9 Unintentional leakage from detachable pipe connections, valves, hose rupture etc. shall not endanger the safety of installation or personnel.

Guidance note:

E.g. protective covers on hoses situated at operator's stand in event of hose rupture, hose rupture valves on systems critical to loss of hydraulic pressure, ignition sources at a safe distance from potential leakage sources of flammable hydraulic liquid systems etc.

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- .10 Local accumulators which are used as back up supply for essential functions shall be designed and located or protected so as to avoid inadvertent isolation or mechanical damage which could prevent correct operation on demand.
- .11 Piping, tubing, and components in systems which are required to operate during 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 system control. Where appropriate, fire test certificates shall be obtained as documentation for such system components.
- .12 Piping and tubing shall be flushed and cleaned before being connected to control systems.

Guidance note:

The cleanliness limit of the hydraulic fluid wetting the internals of a hydraulic system should be established during the design phase.

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- .13 Hydraulic oil return lines shall be designed with sufficient capacity for the maximum return flow during extreme condition without reducing overall system performance. Care shall be taken to avoid the possibility of blockages at filters, vents, by mechanical damage, or by inadvertent operation of valves.
- .14 Hydraulic cylinders for lifting, tension systems or heave compensation shall be in compliance with DNV Standard for Certification 2.9 Type approval program 5-778.93 "Hydraulic Cylinders".

1.4.5 Pneumatic systems

- .1 Components that require better than instrument air quality for operation shall not be used. Extremely small openings in air passages shall be avoided.
- .2 Main pipes shall be inclined relative to the horizontal, and drainage shall be arranged.
- .3 Pipes and other equipment made of plastic materials shall have satisfactory mechanical strength, low thermoplasticity, high oil resistance, and flame resistance properties.
- .4 Instrument air shall be free from oil, moisture, and other contamination. Condensation shall be avoided at relevant pressures and temperatures.

Guidance note:

For air flowing in pipes which are located entirely inside the machinery space and accommodation, the dew point should be more than 10°C below the ambient temperature, but need not normally be lower than 5°C. The dew point of air flowing in pipes on open deck should be below – 25°C.

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- .5 Reduction valves and filters shall be duplicated when serving more than one function (e.g. more than one control loop).

- .6 Local accumulators that are used as back up air supply for essential functions shall be designed and located or protected to avoid inadvertent isolation or mechanical damage that could prevent correct operation on demand.
- .7 Piping and tubing shall be cleaned and dried before connection to control systems.

1.5 Ignition prevention of machinery and electrical equipment

1.5.1 Machinery or electrical installations and other equipment necessary for the drilling operations (e.g. HPU) which are installed in hazardous areas shall be suitable for the intended purpose and shall comply with the requirements of DNVGL-OS-A101 and the relevant DNVGL-OS-D201.

Guidance note:

For mechanical equipment located in an hazardous area, attention should be brought to minimise risk of sparking during normal operation of the equipment, by applying non-sparking materials where relevant (e.g. dice of iron roughneck, braking system of draw works), greasing of wheels (e.g. dolly guide-wheels) etc.

See DNVGL-OS-A101 Ch.2 Sec.2 [4] for protection of diesel engines for use in zone 2 hazardous area.

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1.5.2 Electrical equipment and instrumentation that shall be operable during extended gas danger shall be Ex-rated and designed to operate for the intended time interval. Where this is not feasible, means shall be provided to minimise risk of ignition.

Guidance note:

This applies for e.g. BOP control system located in a safe area. Protection may be provided according to DNVGL-OS-D201 Ch.2 Sec.11 [3.2].

The equipment should be operable for reduced ventilation or cooling when necessary.

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1.6 Emergency stops

1.6.1 Emergency stops shall be located at convenient locations on machinery for immediate use by personnel in the event of a hazardous situation occurring.

1.6.2 Emergency stops shall neither be used as an alternative to proper safeguarding measures, nor as an alternative for automatic safety devices, but may be used as a back-up measure.

1.6.3 All emergency stops shall function according to either of the following principles:

- stopping by immediate removal of power to the machine actuators or mechanical disconnection (declutching) between the hazardous elements and their machine actuator(s); and, if necessary, braking (uncontrolled stop)
- stopping with power to the machine actuator(s) available to achieve the stop and then removal of power when the stop is achieved.

Upon activation, the emergency stops shall automatically result in the hazard being avoided or mitigated in the best possible manner.

Guidance note:

"In the best possible manner" includes, among others:

- choice of optimal deceleration rate
- selection of stop principle (as listed above).

"Automatically" means that upon activation of emergency stop, achievement of the emergency stop function may be the result of a predetermined sequence of internal functions.

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1.6.4 The emergency stops shall, as a principle, overrule all other functions, unless an alternative approach is thoroughly justified on the basis of safety benefit. It shall also ensure that emergency stops are not in conflict with the fail safe philosophy, see [Sec.1 Table 2](#).

1.6.5 Following an emergency stop, it shall not be possible to restart the system before all control devices which have been actuated are reset manually, individually and intentionally.

Guidance note:

For pneumatic/hydraulic machines without system self check possibilities, the reset of the emergency stop should include more than one movement. This may be obtained with an allow-reset function prior to the actual resetting of the emergency stop.

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1.6.6 When an emergency stop is not hardwired, self-check facilities as given in [Sec.1 \[6.1.2\]](#) shall be implemented.

1.7 Automatic start of pumps

1.7.1 Faults in the mechanical or electrical system of the running pump shall not inhibit automatic start of the standby pump.

1.7.2 Automatic start of the standby pump shall be initiated by the process parameter which is being monitored, e.g. low pressure signal, and shall be arranged so that the standby pump does not stop automatically when first started («locking circuit»).

1.7.3 Manual start and stop of the pumps shall be possible without initiation of alarm for automatic start of the standby pump.

1.7.4 When a pump is standby, this shall be clearly indicated on the switch panel by indicating lamps, etc.

1.8 Equipment at height

Equipment installed above the drill floor/above moon pool shall be properly fastened and secured against falling down.

Guidance note:

E.g. securing of bolts against unintentional unscrewing or use of secondary securing devices.

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2 Drilling related structures

2.1 General

2.1.1 Components/structures shall be designed in accordance with recognised codes, standards and guidelines.

2.1.2 Components/structures shall be designed with regard to their intended use, their interaction with or near other components, and their safe use under all known operating conditions including any anticipated overload.

2.1.3 Where flanges and clamp or hub connections are used, consideration shall be given to external loads in addition to internal pressure.

2.1.4 Relevant loads and loading combinations for calculation of structural strength shall be specified in accordance with [Sec.1 \[8\]](#) and [Sec.1 \[9\]](#).

2.2 Drilling structures

2.2.1 Standard design

Standard derrick design for which the hook load is transferred through the derrick structure may be according to the requirements of API Spec 4F, subject to additional consideration of the following (as applicable):

- pre-stress from fasteners
- snow and/or ice loads (including increase of wind induced loads)
- where operational requirements exceed API Spec 4F, wind speeds shall be according to the unit specific operating requirements, and associated wind loads shall be calculated according to the relevant Offshore Standard for structures
- fatigue evaluations

- vortex shedding evaluations
- adequacy of local design strength (i.e. fixture and support) for major equipment fitted on structure, such as pipe handling equipment, heave compensators etc. (Local design strength shall also be included in the design loads for the structure if not listed under API Spec 4F).

2.2.2 Other designs

Other designs of drilling and well servicing structures not covered by API Spec 4F, (e.g. where hook load is transferred directly to drill floor or substructure), shall be thoroughly evaluated for all applicable loads and loading combinations as listed in [Sec.1 \[8\]](#) and [Sec.1 \[9\]](#). Relevant items listed in [\[2.2.1\]](#) shall also apply.

2.2.3 See DNVGL-OS-A101 for requirements for walkways, ladders etc.

2.2.4 Lighting and other electrical equipment in derrick to be either Ex-certified or tripped on gas detection.

2.3 Drill floor

2.3.1 The drill floor is the base structure for the derrick, mast or hoisting structure, and shall be designed to withstand the loads and forces imposed by the hook load, setback area(s), rotary loads, and all installed equipment. Accidental loads shall also be considered, see [Sec.1 \[8.4\]](#)

2.3.2 Adequate local design strength (i.e. fixture and support) shall be specified and documented for major equipment fitted on drill floor, such as rotary table, deadline anchors, drawworks etc.

2.3.3 Relevant combinations of operational and environmental loads as outlined in [Sec.1 \[8\]](#) and [Sec.1 \[9\]](#) shall be specified for all relevant loading conditions.

In particular, setback-loads shall be specified at 100% for survival condition unless a reduction is justified, as time constraints do not normally allow for reducing the setback-loads.

2.4 Substructure

2.4.1 The substructure shall be designed to withstand all combined loads as outlined in [Sec.1 \[8\]](#).

Guidance note:

The interface between the drill floor/substructure (hull) and the derrick/hoisting tower (equipment) will normally be where the flanges of the derrick legs meet the drill floor, or until the welding of a tower leg to the tower leg foundation (the weld itself will belong to the hull part). See DNVGL Rules for Drilling Units and DNVGL-S-0166 for further requirements to drill floor/substructure.

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2.5 Support structure for drilling or well testing equipment

2.5.1 Adequate local design strength (i.e. fixture and support) shall be specified and documented for major drilling equipment fitted such as mud pumps, tensioners, compressors etc.

2.5.2 The flare boom structure shall be designed for loads in both the operating and the stowed condition.

2.5.3 Design of the flare or burner boom structure shall include due consideration of the thermal loads during flaring.

2.6 Lifting of equipment

2.6.1 The intention is to provide guidance for design purpose of lifting of equipment, both during installation and regular lifting, as applicable. See [Ch.3 Sec.3 Table 1](#) for categorization of lifting of equipment.

2.6.2 The design of lifting brackets shall specify maximum sling angle and include resulting bending stresses in the design calculations.

2.6.3 If the lifting force is transferred through the thickness direction of a plate, then plates with specified through thickness property (z-quality) shall be used.

2.6.4 Design requirements for lifting brackets installed on permanently fixed structures also intended for

installation lift(s) shall be as given above, with the exception of lifting brackets potentially used for 2-fall applications, for which the design factor shall be doubled.

Guidance note:

For more detailed requirements, reference is made to other standards or as referenced by relevant national legislation.

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2.6.5 Skids and lifting brackets intended for installation lift(s), only

- .1 Primary structure design of lifting skids used during installation lift(s) shall be specified based on design calculations.

Guidance note:

A design factor DF should be included where:

$$DF = SF \times \psi$$

SF is the safety factor, ψ is the dynamic factor. Unless otherwise specified, the values of DF as given in Table 1 apply:

Table 1 Design factors

Component	Design factor (DF)
Skids	2.5
Multiple point lifting brackets	3
Single point lifting brackets	5

The dynamic factor ψ may be specified in accordance with the actual intended lifting operation. The safety factor SF should, however, never be taken as lower than 1.5 (2.5 for single lifting bracket skids).

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

- .2 Skids and lifting brackets intended only for installation lifts as described above do not require load testing. Means shall be provided to avoid use of such brackets for regular lifting.

Guidance note:

Lifting brackets within this category should not be marked SWL, or otherwise clearly marked (e.g. "for installation lifting only").

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

2.6.6 Skids and lifting brackets intended for regular lifting

- .1 Skids and lifting brackets intended for regular lifting (including maintenance lifting) shall be provided with proper certification.

Guidance note:

ILO Form No. CG3, or equivalent, is one scheme in accordance with international regulations, see e.g. DNV Standard for Certification No. 2.22 Lifting Appliances for further details.

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

- .2 Essential and non-redundant primary structural members, in addition to lifting brackets, shall be welded with full penetration welds.

3 Well control systems

3.1 General

3.1.1 Well control systems are principally designed for use to restore the primary well barrier in those cases where an influx from the formation has entered the well system. Well control systems are used to shut-in or conduct the influx out of the well or the riser system, and to replace mud if necessary.

3.1.2 If formation fluids/gas is planned to be handled through non-conventional systems that are not explicitly covered by this standard, these must be qualified for such operations. The overall risk must be justified to be equal or lower than for conventional well control practice. Requirements of this standard apply as relevant.

Guidance note 1:

Ref. [Ch.2 Sec.5 \[3.3.3\]](#).

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

Guidance note:

See definitions for primary and secondary well control, [Ch.1 Sec.1 \[2.2\]](#).

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

3.1.3 Well control systems can be divided into two sub-categories for drilling systems: Shut-in systems and Low pressure systems.

3.1.4 Shut-in systems normally comprise the following systems:

- blow out preventer system
- choke and kill system
- high-pressure riser system (when used for shut-in pressures).

3.1.5 The shut in system shall as a minimum be designed to withstand the maximum shut in well pressure.

3.1.6 Low pressure systems normally comprise the following systems:

- diverter system
- low-pressure riser system.

3.1.7 The low pressure system shall have a suitable pressure and flow rating, reflecting the worst case conditions it can be exposed to.

3.1.8 The maximum and minimum design temperature of well control systems/equipment shall be specified.

Guidance note:

For choke and kill systems, see API Spec 16C for further guidance.

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

3.1.9 The well control systems, as specified in sub-section [\[3\]](#), with the exception of the riser systems, are defined as safety systems. The riser systems are performing essential functions.

Guidance note:

Some safety functions are supported by drilling systems, ref. [Sec.1 \[2.1.5\]](#). The safety function provided by the diverter system for instance, will normally depend on the low-pressure riser system, e.g. integrity of riser, activation of slip-joint packer, etc. (as relevant).

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

3.1.10 The blowout preventer shall in general consist of the following, as a minimum:

- a BOP stack consisting of:
 - one bag-type or annular preventer
 - one blind shear ram for fixed/anchored units
 - two shear rams for DP units, where one ram is a blind shear ram and the other is a casing shear/super shear ram
 - two pipe rams.
- necessary control equipment as stated in [\[3.2.4\]](#) and [\[3.3\]](#)
- riser connector (LMRP, for floating installations only)
- wellhead connector.

Guidance note:

The arrangement of pipe rams should allow two rams to close around drill pipe and not be hindered by tool joints.

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

3.1.11 For dynamically positioned units, the driller shall always be informed of the vessel position in relation to well centre.

Guidance note:

This status can be given as "traffic light" used by dynamic position system.

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

3.1.12 Special considerations shall be given to vessels operating by dynamic position system in shallow water.

Guidance note:

This consideration can be additional tools or equipment for automatic disconnect. This consideration should include both drive off, drift off situations and riser-disconnect angles.

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

3.2 Blowout prevention

3.2.1 Blowout preventer stack

- .1 The blowout preventer stack shall as a minimum be designed to withstand the maximum differential pressure that it will to be exposed to during drilling and well control operations.
- .2 The blowout preventer stack shall be designed to enable fluids with cuttings and gas to be conducted out of the system, and to enable fluid to be pumped into the system.
- .3 Two valves shall be installed in series close to the blowout preventer stack for each of the choke and kill lines. The valves shall be located so that they are protected against damage from falling objects. Where installed subsea, the valves shall be provided with remote control and shall be of the fail-to-close type.

Where installed surface, the valves shall be according to one of the following:

- two remote valves, both shall be of the fail-to-close type (as for subsea installations)
 - one valve provided with remote control and the other manually operated.
- .4 The shear rams shall be capable of shearing the thickest section of the heaviest drillpipe, casing, slack wire/cable or landing string shear sub specified for use. If tool joints cannot be sheared, either two shear rams must be installed (as for DP units), or lifting or lowering of main hoisting system shall be possible in all operational modes, including emergency operation.
 - .5 Pipe rams shall be designed for any hang-off loads to which they may be subjected.
 - .6 Surface control lines and fittings shall be capable of withstanding a fire for sufficient time for necessary operation of the BOPs.

Guidance note:

If a dimensioning fire is not specified, the requirements of API Spec 16D as a minimum should be applied, i.e. 700°C (1300°F) for 5 min.(API 16D 10.1.2).

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

- .7 Where surface BOPs are used, the lower kelly cock shall be of such a design that it can be run through the BOP stack.
- .8 Shear or blind rams and pipe rams shall be equipped with mechanical locking devices.
- .9 The assessment of the assembled subsea stack drill through column and the individual drill through components shall include evaluation of external load limits resulting from the global riser system (i.e. riser tension and tension variations, riser bending moment and angle of ball/flexible joint) combined with working pressure. Combinations of loads for drilling and non-drilling conditions with the riser connected should be considered in the evaluations.

Guidance note:

The global riser analysis should include, among others; soil stiffness and the characteristic of conductor/wellhead, BOP, ball/flexible joint and riser tension system.

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

- .10 Design of the stack assembly (including the BOP Stack and LMRP as sub-assemblies) shall take into account relevant loads induced by the maximum operational, survival, transit, and accidental heel design conditions specified in accordance with [Sec.1 \[8\]](#). Relevant loading combinations derived from the handling sequence shall be evaluated. Securing arrangements shall be taken into account.

Guidance note:

Design Calculations should be evaluated in accordance with [Sec.1 \[9\]](#). Due consideration should be given to the effects of wave slamming and sea current forces on the guideline system as the BOP is deployed.

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

3.2.2 Riser and wellhead connector

- .2 Emergency operation of the riser LMRP connector shall be available from an additional location to the place of normal operation. The location of the additional control shall be selected such that at least one control point is likely to be accessible in the event of an emergency.
- .3 Hydraulically operated wellhead and riser (LMRP) connectors shall have redundant mechanisms for unlock and disconnect. The secondary unlock mechanism may be hydraulic or mechanical but shall operate independently of the primary unlocking mechanism.
- .4 The maximum tilt angle of riser (LMRP) connector for mechanical freeing shall be stated.

Guidance note:

Friction of guide posts as well as flex joint should be assessed.

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

- .5 For subsea BOP's, unlatching of the wellhead connector shall be protected with a key lock, protective cover or interlock within the control system.
- .6 The requirements in [\[3.2.1\].9](#) apply.

3.2.3 Valves in drill string

- .1 The requirements in .2 to .6 shall be applied unless other means with sufficient pressure rating are provided to prevent back flow in the drill string during all drilling conditions, including both disconnected and connected conditions.
- .2 The drillstem shall be provided with 2 valves located at either side of the kelly or directly below the topdrive (as applicable) with sufficient pressure rating, of which one shall be remotely operated.
- .3 A manual valve in open position for the drillstring shall be available for immediate use at all times.
- .4 If a wrench or other tools are required to close the manually operated valve in .2 and .3, such tools shall be kept in a readily accessible place.
- .5 An open or close drill string safety valve shall be located in open position on the drill floor where it is available for immediate use. The valve shall be of proper size and thread configuration to fit the pipe in use at the time, and shall be capable of withstanding the same well surface pressures as the blowout preventers in use. It shall not be possible to mount this safety valve in a wrong direction.
- .6 Crossovers etc. used when running of other types of pipe (e.g. casing) and forming part of a barrier against back flow shall also have sufficient pressure rating.

3.2.4 Control and monitoring

- .1 The blowout preventers shall be connected to at least two control panels. All control panels shall be mutually independent, i.e. directly connected to the control system, and not connected in series. The control panels shall include controls for at least, but not limited to:
 - diverter operation
 - close or open of all rams, annular preventers and choke and kill valves at BOP including mechanical locking of rams (where applicable).

For subsea BOPs for floating installations, the following additional controls shall be included:

- primary and secondary disconnect of riser connector
- for DP units: an emergency disconnect.

- .2 Activation of the emergency disconnect shall initiate and complete disconnection in the correct sequence.

Guidance note:

The sequence will depend on BOP configuration and operational mode. A typical EDS/EQD sequence will be:

- shear drill string/casing/work string

- disconnect
- close well.

Where

EDS = Emergency Disconnect Sequence/System
EQD = Emergency Quick Disconnect Sequence/System.

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

- .3 Design of emergency disconnect shall take into account required total time for disconnection.

Guidance note:

A EDS/EQD sequence will typically depend on:

- maximum inclination of riser for successful mechanical disconnection
- length of telescopic joint
- emergency disconnect total time (including unsuccessful shearing, if applicable).

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

- .4 One control panel shall be located at the driller's stand.
- .5 A second control panel shall be located at a suitable distance from the driller's stand, and shall be arranged for easy access, including when the control panel at the driller's stand is not functioning or is out of reach.
- .6 Control panels shall give clear indication of blowout preventer status (i.e. open or closed), and shall indicate available pressure for the various functions and operations.

Guidance note:

Indication of open or closed status may be fulfilled by e.g. direct position indication measurement at the BOP, or through flow monitoring.

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

- .7 Control panels shall be fitted with visual and audible alarm signals for:

- low accumulator pressure
- loss of power supply
- low levels in the control fluid storage tanks.

- .8 When the system is started or reset, normal operation shall be resumed automatically.

Guidance note:

E.g. regulators should not lose their set point.

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

- .9 For hydraulic systems, the main unit of the control system, including the pilot valves, shall be situated so as to be shielded from the drill floor or cellar deck. The unit shall be easily accessible both from the drill floor, and also from the outside without requiring entry via the drill floor or the cellar deck. The main unit shall be designed to comply with its requirement for availability and to avoid single failures.
- .10 For electrical or computer based systems, two mutually independent systems shall be installed. This independence shall include all design events.
- .11 The closing unit accumulators for surface and subsea BOPs shall as a minimum meet the capacity requirements (volume and pressure) of API Spec 16D with the following addition: The accumulator capacity requirement shall be based on the 4 larger rams (and not the 4 smaller rams as specified in API Spec 16D). The accumulator capacity calculations shall further be based on method B and/or C in accordance with API Spec. 16D.
- .12 When subsea BOP systems are fitted with a secondary disconnection system in the event of failure of main system during an uncontrolled well situation, the following shall apply:
- it shall be possible to activate the system from a portable unit
 - the secondary disconnection system shall be independent of the main system, including accumulator capacity
 - the system shall be able to perform BOP closure, cutting of drillpipe, and disconnection to enable the unit to move off to a safe location.

- .13 When installed, the secondary disconnection system shall be fitted with a dedicated closing subsea accumulator unit. Such accumulator unit shall as a minimum meet the capacity requirements (volume and pressure) of API Spec 16D with the following addition: If the BOP is fitted with more than one shear ram, the volumetric calculations shall include at least two shear rams, where one is casing shear ram (if installed). The volume and pressure calculations shall be based on the following closing sequence: Closing of two pipe rams, closing of casing shear/super shear (if installed), closing of shear ram, LMRP disconnect. The accumulator capacity calculations shall further be based on method B and/or C in accordance with API Spec. 16D.

- .14 Subsea BOP stacks shall have Autoshear and Deadman systems installed.

Guidance note:

See API Standard 53 and API Spec. 16D for further guidance.

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

- .15 The control system of the blowout preventers shall be designed in such a way that each blowout preventer response time is within acceptable limits according to recognised codes and standards.

Guidance note:

For surface BOPs, this is normally within 30 s (from activation until close function is completed), up to 45 s for annular preventers.

For subsea BOPs, this is normally within 45 s for rams, 60 s for annular preventers.

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

- .16 Subsea BOP systems shall be provided with two independent pods for all BOP hydraulic lines from the main hydraulic unit.

- .17 To prevent inadvertent operation, activation of all functions shall be arranged as required in [Sec.1 \[5.1\]](#). Additionally, for floating installations, the activation devices for riser disconnection and shear rams shall have additional protection against inadvertent operation.

Guidance note:

E.g. hinged covers in front of activation buttons.

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

3.3 Diverter

- 3.3.1** The diverter system should be designed to safely divert flow away from the installation during a well control incident.

Guidance note:

Gas may inadvertently enter the riser in a number of situations that occur during drilling or well control operations.

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

- 3.3.2** Flow line directly from the diverter system to the poorboy degasser is not permitted.

- 3.3.3** In cases where the conventional diverter system is not suitable for safely diverting gas and wellbore fluids away from the installation, an alternative system shall be considered.

- 3.3.4** The design of diverter systems shall take account of possible erosion during operation. For designs deviating from relevant reference code, an erosion analysis might be required. Assumptions for the design of the diverter system shall be stated in the operation manual.

Guidance note:

Parameters to take into consideration include e.g. pipe bends, particle content (p.p.m.), flow rate and required time for operation/evacuation.

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

- 3.3.5** The diverter piping shall have sufficient length to ensure that gas and wellbore fluids are lead away from the installation. Diverter pipe outlets shall be located at a safe distance from potential sources of ignition, and shall not affect other systems that shall be operable during diverter operations. Diverter pipe outlets shall lead to opposite sides of the installation.

Guidance note:

See API RP 64 for further guidance.

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

3.3.6 Control and monitoring

- .1 The diverter system shall at least be connected to a control panel which is manually operable from a place near the driller's stand.
- .2 The diverter control system shall be equipped with an interlock to ensure that the valve in the diverter pipe which leads out to the leeward side is opened before the diverter closes around the drilling equipment and the flow line is closed.
- .3 Valves in the diverter system shall be capable of operation under worst predictable conditions.

Guidance note:

E.g. specified flow, pressure, temperature.

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

- .4 The control system of the diverter shall be designed in such a way that the response time is within acceptable limits according to recognised codes and standards.

Guidance note:

E.g. API Spec 16D: 30 s for packing elements nominal bore of 20" or less, 45 s for packing elements nominal bore > 20".

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

- .5 Accumulator capacity shall as a minimum comply with API Spec 16D or equivalent.
- .6 Necessary back-up shall be provided to ensure availability of the system at all times.

Guidance note:

E.g. isolated accumulators, back-up supply of pneumatically operated valves etc.

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

3.4 Choke and kill

3.4.1 The high pressure side of the choke and kill manifold shall be rated to at least the same working pressure as the rated working pressure of the blowout preventer stack.

3.4.2 It shall be possible to pump mud through the kill and choke manifold, up to the rated pressure of the blowout preventer stack.

3.4.3 It shall be possible to route the returns from the choke and kill manifold through an installed mud and gas separator. It shall also be possible to route the returns through a fixed piping arrangement leading directly overboard (overboard lines).

Guidance note:

Piping arrangement should normally lead to opposite sides of the installation. Alternative arrangements might be accepted after documenting an acceptable safety level.

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

3.4.4 The pressure rating of the overboard lines and associated valves shall not be less than the pressure rating of the buffer chambers of the choke manifold.

Guidance note:

Full pressure of an open ended piping system may be reached through e.g. clogging or supersonic flow velocity.

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

3.4.5 Unintentional pressure build-up in the buffer chamber should be avoided.

Guidance note:

This may be avoided by interlocked valves between mud/gas separator and overboard lines.

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

3.4.6 The mud and gas separator shall be fitted with adequate pressure monitoring and a liquid seal to prevent gas from flowing to the active mud system. The gas vent line shall not have connections to other systems.

Guidance note:

Regulating valve(s) should not be considered suitable due to risk of hydrate plugging.

The vent capacity is dependent on the liquid seal height and diameter of the gas vent line.

The following recommendations apply for normal drilling operations (e.g. excluding HPHT wells):

- liquid seal height should not be less than 3 m (10 ft)
- gas vent line should not be less than 0.2 m (8 inches).

U-tube liquid seals should be fitted with secondary vent pipe at the highest point of the pipe work to avoid siphon effects and in order to dispose possible gas carried through the seal. The secondary vent should be vented to a suitable location, and never into the primary vent.

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3.4.7 The choke and kill manifold and choke and kill lines shall be arranged to enable pumping through one line whilst there is simultaneous flow return over the chokes through the opposite line.

3.4.8 The choke and kill manifold shall be equipped with the following:

- a) At least 3 chokes, of which one shall allow for remote control, and one for manual adjustment.
- b) It shall be possible to isolate and change each choke while the manifold is in use.
- c) One valve for each of the outlet and inlet lines, such that lines to and from the manifold can be isolated.

3.4.9 Where high pressure and low pressure zones meet in the manifold system, 2 valves arranged in series shall be used.

3.4.10 Manifolds for 345 bar or higher pressures shall be equipped with minimum 2 valves before each of the chokes.

3.4.11 The working pressure of the valves shall be the maximum working pressure of the choke and kill manifold.

3.4.12 Choke and kill lines shall be provided from the blowout preventer stack and shall be connected to a choke and kill manifold.

3.4.13 Choke and kill lines with connections, valves, etc., shall be rated to at least the same working pressure as the rated working pressure of the blowout preventer stack.

3.4.14 Choke and kill piping shall be designed to avoid erosion. Directional changes in piping should be done using long-sweep ells and/or targeted elbows and tees.

Guidance note:

See API Standard 53 for further guidance.

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

3.4.15 Control and monitoring

Clear indications of drill pipe pressure and choke manifold pressure shall be available on all kill and choke control stands (remote and local). Choke valve position and drilling fluid pump rate shall in addition be available at the remote control stand.

3.5 Marine riser system

3.5.1 Marine risers shall be designed to withstand applicable combined design loads for the application in the required water depth.

Guidance note:

Relevant loads to evaluate include:

- waves
- current
- riser tensional loads and load variations
- vessel motion
- drilling fluid specific gravity (SG)
- collapse pressure
- handling loads.

See DNV-OS-F201, API Spec 16F, API RP 16Q or equivalent for further guidance.

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

3.5.2 If the riser is to be used for managed pressure drilling, it shall also be designed to withstand the additional pressure variations it can be exposed to.

Guidance note:

See section [Sec.8](#) for further requirements on MPD

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

4 Heave compensation and tensioning system

4.1 General

4.1.1 Sub-section 4 describes the overall requirements for motion compensating equipment and systems for non-fixed drilling units including, but not necessarily limited to, the following:

- marine riser tensioners, including re-coil system
- guideline tensioners/tension winch
- podline tensioners/tension winch
- idler sheaves
- heave motion compensators
- APVs
- control and monitoring.

Systems or components that are not described in further details below shall follow the respective standards in [Ch.1 Sec.1 Table 5](#)

4.1.2 Anti recoil or similar systems (e.g. for deepwater application or dynamic positioned units) shall be regarded as providing an essential function. Heave compensation shall be regarded as an essential function during fixed-to-bottom operations.

Guidance note:

If such operations are not applicable, the function may be regarded as important. This will, however, impose very important operational limitations for such operations.

For semi-active systems (i.e. systems consisting of one active and passive heave compensation system, the active system may be regarded as important also for fixed-to-bottom operations, provided it is completely independent of the passive system (i.e. failure of active part of system is not regarded as critical).

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

4.1.3 Single component failure shall not lead to overall failure of the system.

Guidance note:

E.g. accumulator banks should be sufficiently segregated in the event of leakage of one accumulator bank.

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

4.1.4 Restricted flow in both directions of compensators shall be arranged so as to safeguard against high velocity of pressurised fluid due to e.g. wire rupture, hose rupture etc.

Guidance note:

This may be achieved by means of e.g. a flow restriction valve.

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

4.1.5 Air control panels and accumulators shall be fitted with safety valves.

4.1.6 Air relief lines from safety valves shall be self draining.

4.1.7 Compressed air shall be used only with non-combustible fluids.

4.1.8 Hydraulic cylinders shall be designed both for internal pressure loads, for loads resulting from their function as structural members (incl. possible lateral loads) and comply with the requirements in [\[1.4.4\].14](#).

4.1.9 Necessary condition monitoring of the system shall be provided and be available at the drilling console in order to detect abnormal conditions that may lead to critical failures. Alarms shall be initiated for abnormal conditions.

Guidance note:

Monitoring of the following should be considered, as applicable:

- fluid level of leakage tank
- leakage level (by e.g. trip counter on the leak transfer pump)
- position of cylinder pistons (i.e. stroke position).

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

4.1.10 Power failure during constant tension or heave compensation operations shall not lead to critical failures.

Guidance note:

This may be achieved either by safety systems on the equipment itself, or by other means, e.g. weak link, inline tensioner or site specific analysis for the particular operation.

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

4.1.11 Where applicable, leak transfer pump system shall comply with [1.7].

4.2 Heave compensation

4.2.1 Single failure in passive heave compensation system shall not lead to overall failure of the system.

Guidance note:

E.g. unintentional valve closing:

During normal drilling operation, unintentional locking of e.g. flow restriction valve ([4.1.4]) is not normally categorised as critical.

However, attention should in particular be drawn to locked-to-bottom operations, during which consequences of unintentional locking of the mentioned valve can be severe. Probability reducing measures should therefore be considered, by e.g. having the main hydraulic valve(s) locked open. The maximum allowable operating pressure during such operations should be limited and as means of protection cushioning at end strokes for this, limited maximum pressure should be provided in the design.

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

4.2.2 The system shall be designed to allow for certain loss of fluid during operation.

Guidance note:

E.g. fluid capacity of fluid or gas accumulator should be higher than that of the hydraulic cylinders.

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

4.2.3 For partially active systems, failure in the active part shall not lead to overall failure of the system.

4.2.4 For fully active systems where single failure may lead to overall failure of system, additional means of safety need to be implemented in system/equipment configuration.

Guidance note:

This apply to e.g. active heave compensated draw works used in locked to bottom operations, where additional means of safety may be; dead-line / in-line tensioner, weak link in riser, limit operation to be within stretch limit of riser etc.

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

4.3 Riser tensioner systems

4.3.1 The requirement of single failure in [4.1.3] also applies with one riser tensioner line removed.

4.3.2 Dynamic positioned units shall be fitted with an anti recoil system or equivalent if required by the water depth for drilling operations, see also [4.3.3].

4.3.3 Where applicable (i.e. deepwater drilling), the system shall be designed to prevent any significant upward motion of the riser that may otherwise cause damage to the riser, installations or personnel resulting from the impact.

Guidance note:

The control of such systems may be manual or automatic (e.g. anti recoil system), but it should be operable also after an ESD.

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5 Hoisting and rotating systems

5.1 General

5.1.1 Sub-section 5 describes the requirements for hoisting and rotary systems including equipment such as:

Hoisting system

- drawwork
- hydraulic hoisting system
- crown block or structural parts of compensators
- travelling block or yoke
- drilling hook or adapter
- drill line anchor.

Rotating systems

- rotary swivels
- top drive
- guide dollies
- rotary table.

Systems or components that are not addressed in further requirements below shall follow the respective standards as indicated in [Ch.1 Sec.1 Table 5](#)

5.1.2 Specific functions related to the hoisting system shall be regarded as essential, see [\[5.2.3\]](#) for details.

5.1.3 Brakes relying on mechanical friction shall be properly shielded against possible dirt or spillage which may affect the performance of the brakes.

Guidance note:

For brake discs there should also be a protection against spillage of oil from the brake callipers or wire lubricants onto the brake disc.

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5.1.4 Capacity calculation of the braking system shall be based on the worst allowable conditions for the mechanical components.

Guidance note:

E.g. coefficient of friction, air gap between pad and discs. The coefficient of friction should normally not be taken higher than 0.3, unless justified by appropriate testing.

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5.1.5 Where applicable, emergency stops and automatic stopping shall not impose unacceptable dynamic loads on the system.

Guidance note:

Design dynamic factors applied should be in line with expected maximum peak loads.

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5.2 Hoisting system

5.2.1 The maximum permissible working load for a system of interdependent equipment shall be that of the weakest component of the system, e.g. winches, wire, hooks, pulleys, etc.

5.2.2 Unless more stringent requirements are found in this standard or other applied reference code or standard, the safety factors of wire ropes shall be according to API RP 9B or equivalent. The diameter, construction and tensile grade of the wire rope shall be compatible with the hardness levels and groove profile dimensions specified by the equipment supplier.

5.2.3 The following functions of the hoisting system shall be considered as essential functions:

- braking function
- hoisting or lowering function if facilitating disconnection from well (i.e. successful operation of shear ram)
- heave compensation function if performed by the hoisting system during fixed-to-bottom operations (e.g. active heave compensated drawworks or hydraulic hoisting systems).

5.2.4 Where fitted, wire clamps shall have two gripping areas. The number of clamps shall be in accordance with API RP 9B Table 2.1 or equivalent, but shall not be less than three.

Guidance note:

Other clamping device designs should be according to other appropriate recognised code or standard.

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5.2.5 Drawworks shall be provided with the following functionality:

- Main/Operating braking system
- Emergency stop system.

5.2.6 The Main/Operating braking system, shall have the capability to safely stop maximum rated load at maximum allowable speed, or any other allowable load/speed combination. Further, a mechanical operated main brake which is designed to hold the maximum design load shall be fitted.

Guidance note:

The mechanical operated parking brake should be designed to transfer and hold max design load at minor drum movement. See also [5.1.4] regarding conditions used in capacity calculations.

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5.2.7 For drawworks using brakes relying on mechanical friction as the sole element to meet the capability and performance requirement of the main braking systems, the brake shall be able to produce a minimum static torque equal to or exceeding 200% of static torque resulting from holding maximum rated load with maximum layers of wire rope on the drum.

5.2.8 The hoisting system shall be equipped with a readily identifiable and accessible emergency stop system for use in the event of main brake failure. The emergency stop system shall be independent of the main brake and have functional capabilities to stop, hold and safely lower the load in the event of main brake failure. Emergency brake shall have the higher torque capacity generated by either 200% of static load, or maximum inertia and load with a safety factor of 25%.

Guidance note:

The emergency brake should be designed to account for maximum load and inertia for rotating machinery.

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5.2.9 Where plastic covered wire is used, special consideration shall be given to the number and type of clamps used.

5.2.10 Individual components such as sheaves, hooks, shackles, wire slings, permanent attachments, etc. shall be marked with the safe working load (SWL).

5.2.11 Non-welded cast iron sheaves are normally exempted from impact testing if not required by applied code or standard, ref. Ch.2 Sec.2 [2.5.2].

5.2.12 Maximum expected dynamic loads when brakes are activated shall not exceed the derrick design conditions.

5.2.13 For drawwork drums with simple type cylinder designs, the following shall apply: The hoop stress (S_h) in the barrel shall not exceed 85% of the material yield stress, where:

$$S_h = C \cdot \frac{S}{p \cdot t_{av}}$$

S_h = hoop stress in drum barrel

- S = rope tension under spooling
 p = pitch or rope grooving
 = distance between ropes, center to center, within one layer
 t_{av} = average wall thickness of drum barrel
 C = 0.85 for the first layer of wire, 1.0 for the second layer of wire, 1.3 for the third layer of wire and 1.75 for 4 layers and above.

Guidance note:

The requirement regarding different C – values may lead to different maximum rope tensions depending upon the number of layers spooled on the drum. If this is incorporated in the operational limitations for the draw work means shall be provided to monitor the actual number of wire layers spooled on the drum.

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5.2.14 For other drum designs with e.g. internal stiffeners, other recognised calculation methods should be applied.

5.2.15 The drum flanges shall be designed for an outward pressure corresponding to the necessary lateral support of the windings near the drum ends. Unless a lower pressure is justified by tests, the pressure is assumed to be linearly increasing from zero at the top layer to a maximum value of:

$$p_f = \frac{2 \cdot t_{av}}{3 \cdot D} \cdot \sigma_h$$

- D = outer diameter of the barrel.

5.2.16 The hoop stress calculation shall be based on the maximum number of wire layers on the drum.

5.2.17 *Control and monitoring, hoisting system*

.1 Means shall be provided as necessary to prevent the main hoisting equipment (travelling block or top drive) from being run into the crown block in operations where:

- hoisting and related operations are automated
- the driller and other personnel operating the systems do not have an adequate overview of the operation from the place of operation
- the speed of the operation involved is too high for the operator to react in time.

Guidance note:

Such means may be e.g. an anti-collision system.

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.2 If an anti-collision system is fitted as described in .1 above and when possible collision is detected, the hoisting system shall automatically enter fail-safe mode.

.3 Any critical system failure shall initiate alarm and automatically return the hoisting system to the fail-safe mode relevant for each particular mode of operation.

Guidance note:

Examples: Tripping of el-motors caused by heat, overload etc. should automatically activate brakes if ordinary drilling mode.

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.4 During failure when drawwork is moving without joystick movement, the hoisting and lowering shall be stopped automatically. This does not apply for active drawworks.

.5 When emergency brakes are applied, it is assumed that the motor brakes are disabled.

.6 Necessary condition monitoring of the system shall be provided and be available at the drilling console in order to detect abnormal conditions that may lead to critical failures. Alarms shall be initiated for abnormal conditions.

Guidance note:

Monitoring of the following should be considered, as applicable:

- anti-collision

- slack-wire detection
- failure in the hoisting system
- for fluid cooled braking system: temperature, flow and level
- for electromagnetic brake coils: current and earth leakage
- crown- and floor saver initiation and status
- primary power supply status
- activation of emergency stop.

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.7 The following parameters shall be indicated at the drilling console:

- vertical position of hoisting device
- weight of the drill string
- rate of penetration and drilling depth.

.8 For compensating drawworks, the drawworks shall still be operational after single failure when operating in compensating mode unless an independent compensating means can take over the heave compensation within acceptable time constraint.

5.3 Rotating system

5.3.1 The following parameters shall be monitored and indicated at the drilling console:

- rotating speed and torque.

5.3.2 The Top Drive electric motor shall have an ingress protection grade that is suitable for the intended use and location.

Guidance note:

IP44 will under normal conditions be sufficient.

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6 BOP, pipe and riser handling

6.1 General

6.1.1 Sub-section 6 describes the requirements for BOP, pipe and riser handling systems and includes:

- tongs, grippers, magnets
- horizontal pipe/riser handling (see [6.2] for further details)
- vertical pipe/riser handling (see [6.3] for further details)
- BOP handling (see [6.4] for further details).

6.1.2 Grippers and magnets holding function shall be regarded as an essential function.

Guidance note:

To protect against unintended loss of the holding function, this will normally entail the following:

- To protect against possible operator error, 2 signals from operator may be required to activate opening of gripper or deactivation of the magnets.
- To protect against possible computer hardware and software failure, the requirements of Sec.4 may apply for computers. Exception to this is where the gripper function is activated independently of the computer (hardwired).

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6.1.3 Tongs

- .1 All tongs shall be securely attached to the derrick, mast, or a back-up post and shall be anchored by a wire rope or stiff arm having a minimum breaking strength greater than the breaking strength of the pulling cable or chain.
- .2 Tongs shall be arranged with safety lines. The lines working on the side opposite the safety line shall have a minimum breaking strength greater than the force of the make-up torque.

- .3 All fittings and connections shall have at least the minimum breaking strength of the cable, wire rope, or stiff arm to which they are attached. Knots shall not be used to fasten cable or wire rope lines.
- .4 Power tong pressure systems shall be equipped with a safety relief valve.
- .5 Failure of the torque sensor shall not lead to a critical situation.

Guidance note:

E.g. use of 2 sensors or detection of sensor failure.

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6.1.4 Grippers

- .1 Grippers where frictional forces are required to prevent the load from dropping shall be designed to hold an equivalent of $2 \times \text{SWL}$ by frictional forces in the worst operational direction. Frictional coefficients applied in design calculations shall take into account realistic operational surface conditions (e.g. greasy pipe). The holding power shall be verified through testing.

Guidance note:

Testing of gripper capacity should preferably be done at manufacturer, e.g. during FAT.

This should not be confused with load testing of the lifting appliance.

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- .2 Grippers shall be protected from potential destructive loads that could occur if a gripper with associated pipe/riser load were exposed to additional vertical loads caused by operating the pipe/riser handling systems downwards toward the respective foundations.

Guidance note:

This may be arranged by interlocking the vertical movement of the pipe/riser handling system with the load cell(s) fitted.

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- .3 Power failure shall not lead to loss of gripper function.

Guidance note:

Gripper should be either spring activated to close or hydraulic power back-up should be available.

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- .4 For hydraulically operated grippers, hose rupture valves and hydraulic accumulator or equivalent shall be installed as necessary to maintain gripper function in the event of hose rupture.

Guidance note:

The requirement for e.g. accumulator may be waived for grippers, which maintain satisfactory gripper function in the event of hose rupture, e.g. horizontally operated grippers.

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6.1.5 Magnets

- .1 To ensure sufficient holding capacity for all operational conditions, magnets shall be designed to hold $3 \times \text{SWL}$ at normal operating conditions.
- .2 The holding power for ideal conditions is dependent on type of material, size (diameter or wall thickness), and mass. The holding power shall therefore be verified through testing for each combination of these parameters present in the pipes/risers intended to be lifted.
- .3 To ensure proper contact with the pipe/riser lifted, lifting magnets shall be hinged to the yoke or element to which they are attached, and alignment of magnets shall be ensured.
- .4 Battery back-up shall be provided where necessary and alarm shall be initiated upon loss of back-up power.

Guidance note:

Attention should be paid to requirements for emergency manoeuvring related to the time available before non-permanent magnets are overheated and lose their holding capacity.

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6.1.6 Emergency manoeuvring

Necessary means shall be provided for emergency manoeuvring of each pipe, riser or BOP handling system to a safe stowed position. Unless otherwise justified, it shall be possible to complete emergency

manoeuvring within 10 minutes of the start of the emergency.

6.2 Horizontal pipe and riser handling

6.2.1 Structural design of horizontal pipe/riser handling equipment shall include consideration of all relevant loadings, including rig movements (where applicable), as outlined in [Sec.1 \[8\]](#). The dynamic coefficient ψ shall be in the range 1.3 to 1.6 depending on type of design.

Guidance note:

For overhead or gantry cranes, typical value of ψ is 1.6, whereas for wire rope suspended type cranes, typical value is 1.3. See e.g. *DNV Standard for Certification No. 2.22 Lifting Appliances* for further details.

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Guidance note:

Horizontal pipe/riser handling includes transportation within the pipedeck/riserdeck areas, as well as transportation between pipedeck/riserdeck areas and drill floor. For additional requirements for grippers and magnets see [\[6.1.4\]](#) and [\[6.1.5\]](#) respectively.

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6.2.2 Access to operating areas shall be clearly restricted during equipment operation. This will normally include proper enclosure, visual and/or audible warnings.

Guidance note:

This is particularly important for systems having automated functions (e.g. automatic return to "standby" position upon delivery of pipe/riser).

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6.2.3 If access cannot be restricted, such that the area has to be regarded as normally manned (due to e.g. access through the pipe/riser handling area), the safety features outlined for vertical pipe and riser handling in [\[6.3.2\].1](#) to [\[6.3.2\].4](#) apply.

6.3 Vertical pipe and riser handling

6.3.1 General

- .1 Vertical pipe/riser handling includes equipment such as racking board, standlift arrangement, stand guide arrangement and make-up or break-out arrangement. For additional requirements for grippers and magnets see [\[6.1.4\]](#) and [\[6.1.5\]](#) respectively.
- .2 Equipment such as stabbing boards and baskets are regarded as manriding equipment (see [\[10.3\]](#)).
- .3 The requirement in [\[6.2.1\]](#) applies.
- .4 There shall be provisions for location of drill pipe collars, tubing, rods, and casing.
- .5 The storage racks shall be designed to prevent drill collars, pipe, risers and other tubular material from accidentally being released from the rack.

6.3.2 Safety features

- .1 The requirements in .2 to .4 apply to remotely operated vertical pipe/riser handling systems, where installed.
- .2 The drill floor area shall be regarded as permanently manned, and thus special safety features are required to safeguard personnel during remote pipe/riser handling operations. In particular, the potential for accidents and injuries resulting from single failure shall be avoided.

Guidance note:

Single failures for hardware of the computer based system, including sensors, actuators and associated cables, computer software and operator error should be assessed.

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- .3 If unintended collisions could be caused through automated operations, means shall be implemented as necessary to avoid unintended collisions between e.g. topdrive and racking arms.

Guidance note:

By means of e.g. anti-collision system or interlocks.

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- .4 In case of system failure, the operation of the computer based pipe/riser handling system shall be automatically halted in its present location or brought to a safe location, as appropriate.

Guidance note:

Typically, failure of a positioning device should result in halted operation, whereas loss of battery back-up power to the magnets should result in immediate manual lowering to safe location.

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6.4 BOP handling system

- .1 Design of the BOP carrier or skid shall take into account relevant loads induced by the maximum operational and survival conditions, including maximum static heel for the installation. Securing arrangements during operational and survival conditions shall also be taken into account.
- .2 BOP guiding systems, including wire rope guidelines, shall take into account operational and accidental conditions.

7 Bulk storage, drilling fluid circulation and mixing and cementing

7.1 General

7.1.1 Sub-section 7 describes the overall requirements for bulk storage, drilling fluid circulation and mixing and cementing equipment and systems, and includes, but is not necessarily limited to, the following:

Bulk storage

- dry bulk storage tanks (e.g. cement, barite, bentonite) and associated piping and valves
- bulk transfer system
- surge tanks.

Drilling fluid circulation and mixing

- mud mixing and circulation facilities.

Cementing

7.1.2 Drilling fluid circulation and mixing system to be arranged for emergency and kill circulation and mixing of fluid from mud pits.

Guidance note:

This is typically arranged by using the cement pump for emergency circulation and by having dedicated emergency transfer pumps (with e.g. emergency power supply), which transfer drilling fluid from the mud pits to the cement pump. However, it may also be possible to have an arrangement with one of the main mud pumps and associated feeding pumps dedicated for emergency circulation purposes.

When a DP unit is running on emergency power, the requirement for emergency circulation and mixing may not be relevant, and will have to be evaluated on a case by case basis.

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7.1.3 The capacity and availability of the mud mixing facilities (inclusive passive mud tanks) shall be adequate for the intended drilling program.

Guidance note:

This includes at least:

- ensuring rapid weight increase of drilling fluid in an active system
- mixing sufficient drilling fluid in case of instability in the well
- enabling the drilling fluid to be mixed in order to maintain or re-establish complete well control in a situation where a well barrier is lost and the ordinary power source of the installation has failed, see also [7.1.2] regarding availability of emergency circulation system.

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7.2 Bulk storage

7.2.1 All bulk storage tanks shall be equipped with safety valves or rupture discs to prevent damage due to overpressure. Rupture discs may only be used for bulk storage tanks in open areas, or if fitted with a relief line to an open area.

7.2.2 Safety valves for bulk storage tanks in enclosed areas shall be testable and vented outside the enclosed area.

7.2.3 Means to avoid clogging of bulk material in safety valve relief line shall be presented. This may be obtained by a downward slope of the line or installation of purging possibilities.

7.2.4 Enclosed bulk storage areas shall be sufficiently ventilated to avoid overpressure of the enclosed space in the event of a break or a leak in the air supply system.

7.2.5 The design of atmospheric vessels shall take account of the static pressure developed by vent pipes or similar connections where such are fitted.

7.3 Drilling fluid circulation and mixing

7.3.1 [7.3] describes the overall requirements for drilling fluid circulation including, but not necessarily limited to:

- high pressure mud pumps and pulsation dampeners
- discharge manifolds, lines and valves
- charge pumps
- control and monitoring.

7.3.2 The mud shall be designed and maintained such that the pressure exerted by the mud column in the well shall not unintentionally exceed the expected and verified drilling pressure window of exposed formations.

Guidance note:

For mud as a well barrier/well barrier element, see [Ch.2 Sec.1 \[2.2\]](#).

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7.3.3 Degasser and mud and gas separator shall be vented to a safe location.

Guidance note:

The poorboy degasser vent should be located as high as possible. If this does not provide adequate separation from ignition sources, alternative venting locations or other means of protection should be considered.

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7.3.4 High pressure mud pumps shall be fitted with pulsation dampeners and safety relief valves set at the maximum allowable pressure of the systems.

7.3.5 Mud relief lines from safety valves shall be self-draining.

7.3.6 *Control and monitoring, drilling fluid circulation and mixing*

- .1 Necessary condition monitoring of the system shall be provided and be available at the drilling console in order to detect abnormal conditions that may lead to critical failures. Alarms shall be initiated for abnormal conditions.

Guidance note:

Monitoring of the following should be considered, as applicable:

- mud pump discharge pressure and rate
- weight of mud entering and leaving the borehole
- drilling fluid volume, indicating the increase or decrease in drilling fluid volume
- drilling fluid return indicator, showing the difference in volume between the drilling fluid discharged and returned to the unit. The indicator should be capable of compensating for unit movements
- gas content in the mud.

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- .2 Alarm shall be initiated for abnormal conditions in active drilling fluid tank volume.

Guidance note:

E.g. loss of volume due to loss of circulation, gain in volume due to influx, low level in active tanks.

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- 7.3.7** When the cementing unit is used as means of emergency circulation, facilities for transferring mud to the cementing system shall be provided.

Guidance note:

This includes e.g. mud supply pump, emergency power to the mud supply pump.

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- 7.3.8** The drilling fluid tank volume shall, in all operational modes, be sufficient for the intended well volume.

Guidance note:

Sufficient volume may be ensured by automatic or manual transfer.

Activation time and capacity of the transfer system from the passive tanks should be taken into consideration.

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- 7.3.9** When the transfer is automatic, high level alarm shall be initiated.

7.4 Cementing system

For requirements for cementing system when required during emergency circulation see [7.3.7].

8 Managed pressure drilling (MPD)

8.1 General

- 8.1.1** Sub-section 8 describes requirements for Managed Pressure Drilling systems.

8.1.2 MPD pressure control system as specified in sub-section [8] shall be considered essential. If a function performed by the MPD pressure control system is not related to the well barrier, nor critical for safety, it might be considered important or non-important.

8.1.3 In the scope of this standard, MPD systems shall only be used for overbalanced drilling, which means that formation fluids or -gas shall be continuously prevented to flow into the well.

Guidance note:

Per definition, MPD is not used for underbalanced drilling. For MPD, advanced technologies are introduced for active control of the well pressure, and in this connection an important objective is to always keep the pressure in the well higher than the exposed formation pore pressure.

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- 8.1.4** Introduction of novel MPD technology shall be preceded by a recognized qualification process.

Guidance note:

The process for qualification of new technology is for instance described in DNV-RP-A203 - "Qualification of New Technology".

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8.2 System breakdown

8.2.1 The MPD *pressure control system*, is a system of equipment used in MPD operation to manage and control flow and pressures in the well. Each MPD system shall include a dedicated MPD pressure control system. The MPD pressure control system can be split into four main sub-systems: MPD controller unit (see [8.2.2]), Monitoring system (see [8.2.3]), Dynamic MPD pressure control equipment (see [8.2.4]), and Static MPD pressure control equipment (see [8.2.5]).

Guidance note:

Listed equipment in one of four sub-systems (see [8.2.2]-[8.2.5]) is not necessarily comprising or applicable to all MPD systems. Also, equipment that is not included here may be considered as a part of the MPD pressure control system on a case by case basis.

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8.2.2 The MPD controller unit can involve the following, but not limited to:

- .1 Control logic unit used to perform arithmetic and logical operations, including:
 - Interface to dynamic and static MPD pressure control equipment.
 - Interface to hydraulics and mechanistic models. Hydraulics models that are used to simulate flow, pressures and other parameters in the well or in equipment.
 - Mechanistic models that are used to simulate relevant operational parameters (e.g. torque and drag, rate of penetration, formation conditions, etc.).
 - Interface/connection to drilling control system.
 - Connection to internal well monitor system (e.g. system specific pressure transmitter, flowmeter, level transmitter, etc.).
 - Connection to external well monitoring systems (e.g. downhole measurements).
 - Interface/connection to other relevant systems.

Guidance note:

The MPD controller unit is considered a complex system since all functional and failure response properties for the completed system cannot be tested with reasonable efforts. Systems handling application software belonging to several functions and software that includes simulation calculation and decision support modules are normally considered as complex.

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8.2.3 Well monitoring system can involve the following, but not limited to:

- .1 Measuring devices/sensors used to monitor well and MPD pressure control equipment, e.g.:
 - Pressure and flow transmitters located in the marine riser or in the mud flow lines.
 - Measurements of down-hole conditions, e.g. PWD or MWD data.
 - Other measuring devices for safety, or control of the well barriers.

Guidance note:

The well monitoring system can communicate with external monitoring systems. While internal monitoring systems are normally a part of the MPD system, external monitoring systems, e.g. PWD and MWD tools, are typically provided by service companies.

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8.2.4 Dynamic MPD pressure control equipment, could be but not limited to:

- .1 MPD choke manifold used to regulate annular hydraulic backpressure and mud return flow:
 - Adjustable chokes used to regulate mud return flow.
- .2 Conventional pumps used to pump fluid or cement:
 - Rig pumps used to circulate fluid into the well.
 - Booster pump used to pump fluid into the marine riser.
 - Cementing unit used to pump cement or mud into the well.
- .3 Additional circulating systems connected to the well, used to manipulate mud flow:
 - Back pressure pump used to maintain flow through manual or automated MPD choke manifold.
 - Separate injection line used to mix gas or fluid with the drilling fluid in the well.
 - Subsea pump used to adjust mud return flow.
 - Separate mud return line used to conduct mud return flow back to surface.
 - Bypass line used to conduct and regulate mud return flow.
- .4 Dedicated tools used to restrict flow in drillstring or in well:
 - Inside drillstring valve used to prevent U-tubing between drillstring and wellbore.
 - Valve used to prevent U-tubing between mud return line and well.
 - ECD reduction tool used to reduce the impact of (annular) friction loss on the BHP.

- Additional annular preventer that is not part of the BOP stack used to dynamically seal the well and maintain backpressure.

Guidance note:

General requirements related to drilling fluid circulation and cementing equipment (e.g. mud pumps and cementing unit) are described in [Ch.2 Sec.5 \[7\]](#).

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8.2.5 Static MPD pressure control equipment could be, but not limited to:

- 1 Rotating or non-Rotating Control Device (RCD/NRCD) used to close well system (contain fluid) and isolate backpressure.
- 2 Dedicated annular preventer that is not part of the BOP stack used to seal the well and maintain backpressure.
- 3 Well construction or drilling equipment used to isolate internal well pressures:
 - Drillstring used to prevent unintentional flow between drillstring and well.
 - Non-return valve in drillstring.

8.3 System requirements

8.3.1 The MPD pressure control system (as described in [\[8.2\]](#)) shall be designed, maintained and operated, such that the pressures in the mud flow loop will not exceed the predefined operational pressure limitations.

Guidance note:

This will typically involve valve configuration, piping, PSVs, etc.

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8.3.2 A safety system is required in order to perform safety functions if failure of one or several functions of the MPD controller unit can cause loss of a well barrier or be critical for safety. The safety system will be realized by a *safety logic unit*.

Guidance note:

If the MPD pressure control system is to be used as a part of the well barrier or for safety, it is important to recognize that some of the functions performed by the system are defined as safety functions. An important principle advocated in this context, is the principle of placing safety and non-safety functions in separate (and independent) systems. This does not only relate to the MPD controller unit.

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8.3.3 The safety logic unit, including all components/utilities, shall be designed by the principles as defined in [Ch.2 Sec.1 \[2.1.5\]](#).

8.3.4 The control and safety logic units should be preceded by recognized processes for software integration, including relevant sub-systems (e.g. monitoring systems) and system components, and the effects these have on the overall performance of the drilling processes in terms of functionality, quality, reliability, availability, maintainability, and safety.

Guidance note:

E.g. as described in DNVGL-OS-D203 - "Integrated Software Dependent Systems (ISDS)".

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8.3.5 It shall be documented that the MPD system can be safely operated for all operations for which it will be deployed, i.e. drilling, well control, tripping, drill pipe connection, running of casing, cementing, well completion, shutdown, testing, emergency, and any other relevant operation.

Guidance note:

Preferably it should be possible to convert from MPD mode to conventional mode (and vice versa) without increasing the operational risk. Independent evaluations of existing procedures or risk assessments could be required on a case by case basis.

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8.3.6 A design basis document for the MPD pressure control system shall be submitted for review. It shall as a minimum include the following:

- Functional description of the MPD pressure control system, its interfaces/connection to the rig and other relevant systems.
- Main parameters of the MPD pressure control system (i.e. max pressure rating of equipment, max tension capacity, max flow capacity, accuracy in BHP adjustment (ΔP), lowest kick detection volume, max water depth, etc.).
- That related systems and components are designed and manufactured in accordance with relevant design codes, including appropriate safety factors.
- That related systems and components are compatible with their environments.
- That the MPD pressure control equipment is as a minimum rated to withstand the expected and documented maximum flow and differential pressure it can be exposed to for all relevant operations.
- Limitations of control logic unit and (internal) monitoring systems.
- Other relevant limitations of the MPD pressure control system that may impact the integrity of the MPD system.

8.3.7 A separate design basis document for the safety logic unit shall be submitted for review when a safety logic unit is required. It shall as a minimum include the following:

- description of the safety logic unit
- description of each safety function
- other documentation of relevance (see [8.3.6]).

8.3.8 Components of the MPD pressure control system which are part of a well barrier shall be identified and documented to be in compliance with requirements for well barrier elements.

8.3.9 It shall be documented that well control operations, e.g. handling of well kicks when using the MPD system, as a minimum provides the same level of safety as when using a conventional drilling system.

Guidance note:

This implies that deployed well control systems must be qualified and capable of performing its safety functions when required. For well control systems, see Ch.2 Sec.5 [3.1].

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8.3.10 Risk reducing measures is required for cases where the risk for use of the MPD system is evaluated to be high. By principal, it shall always be possible to regain control of the well independent of the well system. The MPD system shall be documented to have the necessary functions and the needed reliability to be operated under expected and verified conditions.

Guidance note:

Such cases could for instance involve drilling of wells that cannot be drilled using a conventional drilling system. For these, it will not be appropriate to compare the MPD system with a conventional drilling system.

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8.3.11 The MPD pressure control system shall be tested after deployment. Testing shall as a minimum include well barrier elements and other components/equipment that are considered critical for the safety.

The scope and frequency of the testing shall reflect the importance of involved components/equipment or system.

8.3.12 The MPD operator shall log all maintenance and testing of well barrier elements and other components/equipment that are considered and defined as critical for safety. This documentation shall be made available upon request.

Guidance note:

MPD systems that have limited field experience need to demonstrate reliability over time. Range of application may be extended for MPD systems with reasonable field experience. This will be considered on a case by case basis.

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9 Well testing and associated well control system

9.1 General

9.1.1 For general requirements for drainage, blowdown system and shutdown, see DNVGL-OS-E201.

9.1.2 Sub-section 9 only apply for well testing of limited duration. For extended well testing (EWT), see DNVGL-OS-E201.

Guidance note:

Typically, a duration of a well test exceeding 1 month is considered as an extended well test.

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9.1.3 For requirements for supporting systems not listed in this sub-section, see other relevant sections in this standard.

9.2 System requirements

9.2.1 Units designed as, or potentially to be operated as, atmospheric units shall include design features to prevent return of air into the unit, which could cause an explosive mixture or backfiring to occur.

9.2.2 The interconnecting piping system shall be permanently installed with an effort to minimise elastomers in the connections. Permanently installed piping shall be covered with grating wherever appropriate to provide a safe working environment.

9.2.3 Unless more stringent requirements apply, any water dumped overboard at offshore location shall contain less than 40 ppm of hydrocarbons. Discharged water shall be sampled and the hydrocarbon content measured.

9.2.4 API RP 14C or an equivalent standard shall be used as a guideline to safeguard the surface process equipment.

9.2.5 The main process equipment area shall be banded to prevent any oil spillage from spreading outside the dedicated process area. The requirements for drainage in DNVGL-OS-E201 shall be applied.

9.2.6 Where piping installations include a change of pressure rating ("spec. break"), the lower rated pipe shall be adequately protected against overpressure. Double isolation valves shall be installed where practicable.

9.2.7 All surface pressure-containing piping and vessels shall be arranged and mounted in such a manner that blow-down of the equipment can be manually activated from a safe area.

9.2.8 Tripping of and alarms of the ESD system shall be available both locally and at the main control room.

9.2.9 There shall be an inlet ESD valve to isolate the test facilities from the well.

9.2.10 During well testing, the maximum attained shut in pressure shall not exceed the design pressure of relevant (pressure boundary) equipment.

9.2.11 The ESD valves shall be designed for fire exposure, and shall be of fail-safe close type.

9.2.12 Air compressors shall be suitable for installation in zone 2 areas.

9.2.13 The master valve shall, when installed, have the function of emergency shutdown valve. See also [9.2.9].

9.2.14 A check valve should be installed in the final flow segment (i.e. upstream steam exchanger, separator).

9.2.15 Where double PSV's are used, each shall provide 100% capacity. The PSV's shall be interlocked or locked open, as appropriate.

9.2.16 To avoid overpressure, a PSV shall be fitted between the choke manifold and the steam exchanger, unless the maximum allowable working pressure for the piping and steam exchanger is greater than the maximum shut in tubing pressure of the well.

9.2.17 Two valves in series shall be fitted in possible bypasses of pressure reducing devices (as for example chokes).

9.2.18 Heat exchangers shall be equipped with safety valves.

9.2.19 The swivel and kelly hose (rotary hose) shall not be a part of the test line.

9.2.20 At least two complete flare lines, or other devices through which any flow from the well may be directed, shall be provided. These lines or devices shall run to different sides of the drilling unit.

9.2.21 Any flare line or any other line downstream of the choke manifold shall have an internal diameter not less than the internal diameter of the largest line in the choke manifold.

9.2.22 Arrangements for cooling of flare burners shall be available.

9.2.23 The flare burners shall be located at a safe distance from the unit, and this distance shall be justified by means of heat intensity calculations.

9.2.24 Where used, compressed air supply to burner assemblies shall be designed so as to prevent hydrocarbon contamination of the compressed air systems.

9.2.25 For capacity requirements of fire water or deluge system for well test area, see DNVGL-OS-D301.

9.2.26 For general requirements for ESD system, see DNVGL-OS-A101 and the relevant DNV GL standard for electrical systems and equipment.

9.2.27 The suitability of the following aspects should be thoroughly evaluated prior to installation of well testing system and associated equipment on an offshore installation:

- area classification
- location assessed in relation to air intakes, lifeboats, control room etc.
- deluge and passive or active fire protection
- drain system
- fire and gas detection system
- ESD and safety philosophy
- deck loading
- sea fastening of equipment.

10 Man-riding equipment

10.1 Scope

For the purposes of this standard, man-riding equipment includes lifting appliances intended for lifting of personnel, and having a height of fall above 3 m.

Guidance note:

This includes equipment such as man-riding winches, stabbing boards, access baskets, etc.

Lifts are excluded and are to be according to applicable regulations for the unit it is to be installed on. If the lift is to be certified by DNV GL, DNV GL's Rules for Certification of Lifts in Ships, Mobile Offshore Units and Offshore Installations will normally apply.

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10.2 General requirements for man-riding equipment

10.2.1 The safety factor for all load bearing parts of structures, machinery components and lifting devices (including lifting lugs) for man-riding equipment shall be two times that required for other lifting appliances and lifting devices.

10.2.2 All relevant design loads shall be taken into consideration for all operational and non-operational modes. The maximum environmental loads during which the equipment is designed to operate shall be clearly stated.

10.2.3 The total vertical dynamic loads may be obtained by one of the following options, with the most stringent to be chosen, including use of safety factor:

a) $2 \times S_L \times \psi_L + S_G \times \psi_G + S_M$

b) $S_L \times \psi_L + S_G + S_M$

Where

ψ_L = dynamic factor on live load

ψ_G = dynamic factor on self weight

S_L = Live working load

S_G = Self weight of the lifting equipment(s)

S_M = Inertia loads due to motion of the vessel

a) Normal safety factors can be applied if real dynamic factors are used. (Factors taken from actual dynamic testing).

b) Double safety factor shall be applied if calculated dynamic factors are used.

10.2.4 All machinery systems lifting personnel shall be fitted with two separate independently operated braking systems. Each brake shall be capable of stopping and holding the load upon activation. Where cylinders are used for luffing, folding or telescopic, they shall be provided with a hydraulic shut-off valve.

Guidance note:

See DNV Standard for Certification No 2.22, Lifting Appliances, Ch.2 Sec.9, 5.1.6.

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10.2.5 The potential for accidents and injuries resulting from single failure shall be avoided.

Guidance note:

Single failures for hardware of the computer based system, including sensors, actuators and associated cables, computer software, and operator error should be assessed.

Lines where hose rupture may be critical (e.g. casing stabbing basket) should be fitted with a hose rupture valve or equivalent means of protection against uncontrolled lowering.

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10.2.6 Platforms, ladders and other access routes associated with entering the man riding device, shall comply with recognised safety standards or regulations.

10.2.7 Wire-fitted systems where slack wire may be critical shall for all operating modes be provided with

slack wire detection, which initiates automatic stop when activated. Unless other means are proven to be safer, deactivation of this system shall only be possible directly on the winch, and in the presence of an operator, i.e. the detection system shall automatically re-activate when operator is no longer present at the winch.

10.2.8 If brakes relying on mechanical friction are fitted, see [5.1.3].

10.3 Control system for man-riding equipment

10.3.1 The motion regulating equipment shall be smooth, continuous and repeatable. The winch shall not be operable at a speed above the maximum operating speed for safe transport of personnel, e.g. through use of speed limiting devices. The maximum acceleration or deceleration and braking, including emergency braking, shall neither injure nor harm personnel being transported.

10.3.2 Control panels for man-riding equipment shall include all necessary devices for normal operation of equipment, including emergency stops. Operating panels shall be situated at convenient locations, clearly marked, and control handles or equivalent shall return automatically to stop position when not being operated. For wireless remote control systems, see Sec.4 [3.1.4].

10.3.3 Inadvertent operation shall not be possible.

Guidance note:

This may be arranged by means of an enable function prior to the activating action or by activation of 2 devices simultaneously.

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10.3.4 Load limiting devices shall be fitted to prevent loads above SWL from being lifted. Frictional couplings shall not be used for this purpose.

Guidance note:

For hydraulic and pneumatic systems, this may be accomplished by means of a PCV on the supply line.

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10.3.5 Hydraulically operated systems shall be designed to remain safe and stable during all operating conditions, including loss of power and emergency operation.

10.3.6 Emergency stop shall be implemented according to [1.6].

10.3.7 The control (manoeuvring) position(s) shall be located such that the operator has an unobstructed view of the working range of the equipment. If this cannot be accomplished, persons being lifted shall at all times have ready access to an emergency stop device.

10.3.8 The person being lifted shall have the possibility to operate and override the same functions as those operated at the remote operating panel(s).

Guidance note:

This requirement is not applicable to man-riding winches.

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10.3.9 Means of safe return of personnel by override of local control from a remote operating position shall be installed.

10.3.10 The system shall be provided with means which will automatically stop lifting outside the safe operating limits.

Guidance note:

This may be provided e.g. by means of limit switches.

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10.3.11 Controlled lowering of the lifting device shall be possible in the event of power failure or other unintended stop to ensure safe escape from the lifting device. Frictional coupling or clutch shall not be used for emergency operation.

Guidance note:

Alternative means of escaping the lifting device may be accepted. This might be escaping a basket by man-rider winch or by emergency climbing rope. The solution chosen will be evaluated on a case-by-case basis.

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10.3.12 Provision for emergency hoisting shall be present where this may be required for safe escape during an emergency.

Guidance note:

E.g. if operating under deck or over open sea where evacuation possibilities are poor upon lowering.

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10.3.13 Both emergency lowering and hoisting shall ensure the safe escape of person(s) lifted within 10 minutes of the start of the emergency. The lowering and hoisting speed should not exceed 1.0 m/s.

10.4 Specific requirements for man-riding winches

10.4.1 A man-riding winch includes winch with foundation, drum and driving gear, wire rope, sheave arrangement, and lifting tool to be connected to the lifting arrangement.

10.4.2 Arrangement

- .1 The arrangement shall be such that the weight of wire rope between sheave arrangement and winch never exceeds the weight of wire rope and man riding device on the other side of the sheave arrangement. This may be accomplished by means of counterweights. Such counterweights shall be arranged to avoid interference or jamming with other components, or potential for personnel injury.
- .2 The sheave arrangement with fastening to structure shall be dimensioned according to the same principle as the winch itself. The geometry shall ensure free path for the person lifted or lowered and ensure no damage to wire rope. The geometry shall ensure that the angle between wire rope and drum or sheave is within $\pm 4^\circ$. The sheave arrangement shall be fitted with protection ensuring that derailing of wire rope does not occur. The diameter ratio between sheave and wire rope shall be minimum 18:1.
- .3 Winches used for man-riding equipment shall be designed with fixed operation up and down (i.e. no free fall with brakes).
- .4 Man-riding winches designed to lift one person in a riding belt shall have a maximum SWL of 150 kg.

10.4.3 Drum and wire

- .1 Spooling apparatus shall be fitted as necessary to ensure satisfactory spooling of wire rope and to prevent derailing of wire rope.
- .2 The diameter ratio between drum and wire rope shall be minimum 18:1.
- .3 Wire ropes shall have a minimum breaking strength of $10 \times$ SWL and shall otherwise be in accordance with a recognised standard applicable to the intended use. The wire rope shall have a diameter of minimum 10 mm.
- .4 At least 3 turns of wire rope shall remain on the drum at the lowest possible operating position of lifting device.

10.4.4 Brakes

- .1 The winch shall be equipped with two mechanically and functionally independent braking system, of which one is considered as parking brake and the other as operational brake. Each brake shall be capable of stopping and holding the load upon activation.

Hydraulic restriction may be considered as one of the required two brakes, provided the rated capacity does not exceed 50% of the rated capacity for lifting of loads.

Where hydraulic restriction is used as a brake, the following applies:

- The hydraulic motor shall have a closing valve directly at the high-pressure (load) connection (no pipe or hose connection in between).
- The closing valve shall close as a result of pressure loss at the low-pressure connection (inlet connection during lowering). This function shall be accomplished by direct bore or piping between the closing valve and the low-pressure connection.

- The hydraulic motor shall always be ensured sufficient working fluid, also in the event of power failure, i.e. gravity feeding.
- .2 Each brake shall automatically engage upon emergency stop, power loss, or other related energy failure (e.g. hydraulic accumulator, spring, etc.). During normal operation, the parking brake may be operated manually.
- .3 Each brake shall be capable of holding a static load of $1.8 \times \text{SWL}$.
- .4 The brakes should preferably be fitted directly on the drum. If this is not feasible, all components transmitting brake forces shall be dimensioned as the brake itself.
- .6 The brakes shall be designed to avoid unintentional release.

Guidance note:

E.g. an unintentional pressure build-up in excess of the preset maximum return pressure caused by e.g. restricted flow in the return line may typically cause release of the parking brake.

Monitoring of return pressure with initiation of alarm if preset maximum return pressure is exceeded or dedicated return line may be considered.

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10.5 Additional requirements for other man-riding equipment

10.5.1 A casing stabbing board shall be fitted with an additional mechanical locking device, which will safely stop and hold the board in the event of main hoisting system failure.

10.5.2 The failure of a roller or wheel on a man-riding platform or trolley shall not endanger the safety of the rider.

10.5.3 Stabbing boards, access baskets, etc. are to be provided with control panels both locally at the platform /basket and at a suitable remote location.

11 Other systems

11.1 Winches

11.1.1 Sub-section [11.1] is applicable to all winches within the drilling area, except those used for man-riding purposes (see [10]), but including winches used for integrated purposes.

11.1.2 All winches located in normally manned areas shall be shielded for personnel protection and marked with the maximum permissible working load (SWL).

11.1.3 Winch operation shall be by means of an operating handle or equivalent (e.g. push button) which will return automatically to the stop position when not being manually operated. The stop position shall be clearly marked.

11.1.4 Winches shall have an automatic brake which comes into operation in the event of a power supply failure. The brake shall be able to stop the winch at full speed when lowering the maximum load.

11.1.5 Controlled lowering of the lifting device shall be possible in the event of power failure or other unintended stop. Frictional coupling or clutch shall not be used for emergency operation

11.1.6 The winch brake should preferably be fitted directly on the drum. If this is not feasible, all components transmitting brake forces shall be dimensioned as the brake itself.

11.1.7 The air supply to air-powered winches shall not exceed the pressure which is sufficient to reach the SWL.

11.1.8 The brake shall be designed to be capable of holding a static load of $1.8 \times \text{SWL}$.

11.1.9 All load bearing components of the winch, including those transmitting brake forces, shall normally be supplied with traceable material work certificates (3.1), ref. Ch.2 Sec.2 [4].

11.1.10 If brakes relying on mechanical friction are fitted, see [5.1.3].

11.1.11 When spooling operation is not directly visible for the operator of the winch, fitting of spooling

device should be considered.

11.2 Gear transmissions

Non-redundant gear units transmitting braking forces for critical applications shall have documented mechanical strength based on a recognised code and according to a relevant load spectrum (i.e. load-time characteristics). The load spectrum shall include both operational loads and possible brake loads.

Guidance note:

Gear transmissions for “non-critical” application, as for example units for non-hoisting purpose, may be accepted without such documented design.

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SECTION 6 MANUFACTURE, WORKMANSHIP AND TESTING

1 General

1.1 Application

1.1.1 This section covers equipment, structures and systems during fabrication, installation and final testing onboard.

1.1.2 Equipment, structures and systems shall be fabricated, examined and tested according to this section and the applied codes and standards.

1.2 Quality assurance and quality control

The manufacturer shall utilise the necessary production facilities, qualifications, procedures, and personnel to ensure that the product will be manufactured to the specified requirements.

1.3 Marking

All equipment shall be clearly marked with identification and serial number which relates the equipment to certificates and fabrication documentation.

Guidance note:

Low stress stamping may be required for certain materials. Paint markings may be accepted, but care must be exercised during handling and storage to preserve the identification.

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2 Manufacture

2.1 Qualification of welders

2.1.1 Welding of pressure containing components, piping systems, load carrying equipment and structures shall be carried out by qualified welders only.

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

Guidance note:

Welders qualified to another code than the design code may be suitable provided that the design code is demonstrated to be suitable and relevant qualifications are documented.

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2.1.3 The manufacturer shall supply each welder with an identification number or symbol to enable identification of the work carried out by each particular welder.

2.2 Welding

2.2.1 All welding shall be performed in accordance with a welding procedure specification (WPS). The welding procedure qualification test for drilling equipment shall be approved in accordance with DNVGL-OS-E101. One of the following standards shall be fulfilled; DNVGL-OS-C401 or ISO 15614, alternatively AWS D1.1 or equivalent standard.

The qualification shall in addition to primary and essential steel structures include structural category secondary steel welded towards primary or essential steel. Overlay-/clad welding and wide gap welding shall be qualified as required in DNVGL-OS-C401.

Guidance note:

The scope of this standard is covering drilling equipment including the derrick/hoisting tower itself, and normally until where the flanges of the derrick legs meet the drill floor, or until the welding of a tower leg to the tower leg foundation (the weld connecting the foundation will belong to the hull structure). With regards to qualification of welding procedures, DNVGL-OS-C401 will apply to the derrick substructure and foundations.

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2.2.2 All welding operations shall be carried out in accordance with an approved welding procedure

specification WPS, as specified in [2.2.1]. The extent of the welding procedure shall be agreed before the work is started.

2.2.3 Fabrication welding production test (WPT) shall be provided where necessary to verify that the produced welds are of acceptable quality.

2.2.4 The welding of drilling derrick and flare booms shall be in accordance with relevant section of the *DNV Standard for Certification No. 2.22 Lifting Appliances*.

2.2.5 Butt welded joints shall be of the full penetration type. Special provisions shall be taken to ensure a high quality of the root side.

2.2.6 If supports and similar non-pressure parts are welded directly to pressure retaining parts, the welding requirements for the pressure retaining parts shall be applied.

2.2.7 Welding repairs shall be performed according to a qualified and approved repair procedures.

2.3 Heat treatment

2.3.1 After forming and/or welding, the component shall be heat treated if required according to the applied code or standard, or if found necessary to maintain adequate notch ductility and avoid hydrogen induced cracking.

2.3.2 Heat treatment documentation shall include heat treatment temperature, heat treatment time at temperature and cooling media.

2.3.3 A normalising heat treatment shall be applied for hot formed parts, unless the process of hot forming has been carried out within the appropriate temperature range, duration, and cooling rate.

2.3.4 The heat treatment for cold worked materials shall be selected with respect to the degree of plastic deformation in the material.

2.3.5 Preheating and/or post weld heat treatment shall be used when necessitated by the dimensions and material composition.

2.3.6 Post weld heat treatment (PWHT) shall normally be performed in a fully enclosed furnace. Local PWHT may be performed on simple joints when following a qualified procedure.

2.3.7 In the case of defects revealed after heat treatment, new heat treatment shall normally be performed after repair welding of the defects.

2.3.8 A heat treatment procedure associated with forming and/or welding which is not covered by the applied code or standard shall be thoroughly reviewed.

2.4 Pipe bending

2.4.1 The bending procedure shall be such that the flattening of the pipe cross section and wall thinning are within acceptable tolerances specified in the applied code and standard.

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

3 Non-destructive testing (NDT)

3.1 General

3.1.1 The extent of NDT shall be in accordance with relevant codes, standards, or agreed specifications. Where the extent of NDT is not specified, [Table 1](#) and [Table 2](#) shall be used for guidance.

NDT procedures and acceptance criteria shall be according to relevant codes, standards, or other

independently agreed specifications.

Table 1 Extent of NDT for welding of pressure retaining components and piping

<i>Limitations</i>	<i>Weld joint</i>	<i>Radiography</i> ¹⁾	<i>Magnetic particle</i> ²⁾
$P \geq 50$ $t \geq 38$ $T \geq 400$ $\sigma_t \geq 520$	L	100%	100%
	C	100%	100%
	B		100%
$10 < P < 50$ $16 < t < 38$ $T > 150$ for flammable or toxic fluids $T > 220$ for other fluids $\sigma_t > 460$	L	20%	20%
	C	10%	10%
	L+C	20%	
	B		100%
$P \leq 10$ $\sigma_t \leq 460$ and flammable or toxic or compressed air	L	10%	10%
	C	5%	5%
	L+C	10%	
	B		100%
1) Ultrasonic method may be used where practicable and radiography does not give definitive results. 2) Magnetic particle method is preferred. Liquid penetrant method may be accepted as an alternative. For non magnetic materials liquid penetrant method shall be used. P = pressure in bar t = thickness in mm T = temperature in °C σ_t = ultimate tensile strength in N/mm ² L = longitudinal C = circumferential $L+C$ = crossing between longitudinal and circumferential B = branches and reinforcement rings.			

Table 2 Minimum NDT for structural welds

<i>Category of member</i>	<i>Types of connection</i>	<i>Test method</i>			
		<i>Visual inspection</i>	<i>Magnetic particle</i> ¹⁾	<i>Radiography</i> ²⁾	<i>Ultrasonic</i>
Special or non-redundant	Butt weld	100%	100%	100%	-
	Cross-and T-joints, full penetration welds	100%	100%	-	100%
	Cross-and T-joints, partial penetration and fillet welds	100%	100%	-	-
Primary	Butt weld	100%	20%	20%	-
	Cross-and T-joints, full penetration welds	100%	20%	-	20%
	Cross-and T-joints, partial penetration and fillet welds	100%	20%	-	-
Secondary	Butt weld	100%	spot ³⁾	spot ³⁾	
	Cross-and T-joints, full penetration welds	100%	spot ³⁾		spot ³⁾
	Cross-and T-joints, partial penetration and fillet welds	100%	spot ³⁾		
1) Liquid penetrant testing to be adopted for non ferromagnetic materials. 2) May be partly or wholly replaced by ultrasonic testing upon agreement. 3) Approximately 2 to 5%.					

3.1.2 NDT shall be carried out by qualified operators.

3.1.3 When post weld heat treatment is required, final NDT shall normally be performed after heat treatment.

3.1.4 The final NDT shall be performed prior to any possible process which would make the required NDT impossible, or which could have caused erroneous results (e.g. coating of surfaces).

3.1.5 If the NDT examination reveals a defect requiring repair, additional testing shall be carried out in accordance with the applied code or standard, unless otherwise justified.

3.1.6 All performed examination and results shall be systematically recorded and fully traceable.

3.1.7 In addition to above, magnetic particle examination (MPE) is required if the carbon equivalent for the actual material is:

$$C_{Eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15} > 0.45$$

The extent of MPE testing shall be 100% during initial phase of production, in order to prove absence of surface cracks.

4 Testing

4.1 Testing of weld samples

Mechanical testing of weldments shall be carried out by competent personnel and only in accordance with DNVGL-OS-C401 or the applied code or standard.

4.2 Pressure testing

4.2.1 Pressure containing piping and components shall be subject to a hydrostatic pressure test in accordance with applied codes and standards.

4.2.2 The test pressure shall be determined by the working pressure. This shall be minimum $1.5 \times$ maximum working pressure if not otherwise specified in applied codes and standards.

Guidance note:

This requirement may be waived for small bore piping for instrumentation etc. where justified and reviewed on a case-by-case basis. Aspects to consider are maximum operating pressure compared to design pressure, and experience with workmanship.

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4.2.3 The holding time shall be minimum 15 minutes, and shall at least be sufficiently long to allow for thorough visual examination after the pressure has stabilised. A shorter holding time can be considered for very small components in accordance with recognised standards.

4.2.4 The pressure and holding time results shall be systematically recorded and documented so as to be fully traceable.

4.2.5 Where hydrostatic pressure testing of piping represents particular problems, alternative suitable test methods may be applied where justified as suitable.

4.3 Load testing

4.3.1 All lifting appliances shall be tested in "as installed" condition prior to first use.

4.3.2 The test load applied to a lifting appliance shall exceed the safe working load (SWL) of the appliance in tonnes, t, as given in Table 3.

Table 3 Test load for lifting appliances

SWL	Test load
SWL ≤ 20 t	1.25 × SWL
20 t < SWL ≤ 50 t	SWL + 5 t
> 50 t	1.1 × SWL
Man-riding equipment	2 × SWL

Guidance note:

Where justified in applied recognised code or standard (e.g. API Spec 8C), drilling hoisting equipment (main hoist) that is subject to independent design and fabrication verification may be accepted without a proof load test.

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4.3.3 Man-riding equipment (stabbing basket, manrider winch etc.) shall be load tested in the following manner:

- 1) Static brake capacity test for all brakes operating simultaneously at $2 \times \text{SWL}$.
- 2) Static brake capacity test for each individual brake at $1.8 \times \text{SWL}$.
- 3) Dynamic brake capacity test for each individual brake at $1.25 \times \text{SWL}$.

Guidance note:

This dynamic brake capacity test is normally to be performed with full lowering speed and quick stop (e.g. release control rapidly/push emergency stop).

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4.3.4 The equipment with test load, shall be hoisted, slewed and luffed at slow speed through the entire operating range, as applicable for the lifting appliance in question.

4.3.5 Gantry and travelling cranes, together with their trolleys as applicable, shall be traversed and travelled over the full length of their track.

Guidance note:

This requirement also applies to other lifting appliances on tracks, e.g. pipe rackers, standbuilding arms, laydown systems, etc.

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4.3.6 Tests for lifting appliances where the SWL varies with operating radius shall generally be performed with the appropriate test load at maximum, minimum and at an intermediate radius.

4.3.7 All items of loose gear and accessories, such as shackles, blocks, hooks etc. with a SWL larger than 500 kg, and that have not been subject to design review, shall be proof load tested to 200% of SWL and thoroughly examined prior to use.

4.3.8 The flare boom shall be tested with an overload of 25% related to the required weight of burner and spreader. This overload test shall demonstrate that the boom is capable of carrying out motions such as slewing, hoisting etc. as relevant.

4.3.9 Overload protection systems that may have been disconnected during load testing shall be reconnected and safety valves and/or electrical circuit-breakers shall be adjusted after testing. Set points shall be verified and sealed by the surveyor.

4.4 Functional testing/integration testing

4.4.1 All systems, including associated control, monitoring and safety systems shall be tested as far as possible prior to start of actual drilling operations.

4.4.2 Systems shall be function tested under working conditions in accordance with approved test programs. Testing of all safety functions shall be included.

Guidance note:

For equipment not subjected to overload test, functional testing is normally to be performed with full load rating.

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4.4.3 Tests shall as a minimum include adjustment of controllers, calibration of sensors and alarms, function and system testing of protection systems.

4.4.4 The status of tests shall be recorded in an auditable manner and a system to control status of remedial and outstanding work shall be established.

4.4.5 Blowout preventers with control system shall be tested for capacity and performance. Shear rams shall be tested to show that they will be capable of shearing the heaviest and toughest drill pipe to be used.

Guidance note:

See [Sec.5 \[3.2.1\].4](#) for specific requirements.

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4.4.6 Magnets used for lifting purposes shall be tested against accidental drop of pipe by turning the power supply on or off.

5 Testing of electrical systems

Testing of electrical installations shall be conducted according to DNVGL-OS-D201, as applicable.

6 Testing of control and monitoring systems

Testing of control, monitoring, safety and telecommunication systems shall be conducted according to DNVGL-OS-D202, as applicable.

CHAPTER 3 CERTIFICATION AND CLASSIFICATION

SECTION 1 INTRODUCTION

1 General

1.1 Structure

This chapter is divided into 3 main sections:

Sec.1 Introduction: Explains how this standard shall be applied in connection with offshore certification and classification.

Sec.2 Documentation requirements: Identifies specific requirements to be applied when using this standard for certification or classification purposes, as well as stating corresponding documentation requirements.

Sec.3 System and equipment certification: States certification requirements for systems and equipment in certified or classified drilling plants and gives a criticality ranking of such equipment.

1.2 Introduction

1.2.1 As well as representing DNV GL's interpretation of 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.

1.2.2 A complete description of principles, procedures, applicable class notations and technical basis for offshore classification is given by the applicable Rules for classification of offshore units, see [Table 1](#).

Table 1 DNV GL Rules for classification - Offshore units

No.	Title
DNVGL-RU-OU-0101	Offshore drilling and support units
DNVGL-RU-OU-0102	Floating production, storage and loading units

1.2.3 Classification procedures and requirements specifically applicable in relation to the technical provisions in [Ch.2](#) are given in this chapter.

1.2.4 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 Certification and classification principles

Drilling plants will be certified or classified based on the following main activities:

- design verification
- fabrication survey and equipment certification
- survey during installation and commissioning.

1.4 Class designation

1.4.1 Offshore units and installations fitted with drilling plants which have been designed, constructed and installed in accordance with the requirements of this standard under the supervision of DNV GL will be entitled to the class notation **DRILL**.

Guidance note:

Appendix A is for Workover and Well Intervention systems and relates to class notations **WELL-1/WELL-2** and **WELL(N)**. Appendix A is not required for **DRILL** respectively **DRILL(N)**. For further clarifications on class scope see Rules for Drilling and Support Units and DNVGL-SI-0166-OSS-201.

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1.4.2 DNV GL may accept decisions by national authorities as basis for assigning class.

1.5 Assumptions

1.5.1 Classification is based on the assumption that the drilling plant will be properly maintained and operated by qualified personnel, that operational and testing procedures are followed and that loads and environmental conditions during operation will be within the specified design limits.

1.5.2 Any deviations, exceptions and modifications to the design codes and standards given as recognised reference code shall be documented and approved by DNV GL.

1.5.3 Where codes and standards do not call for specific extent of critical inspection and testing, agreed testing or inspection scope between contractor or manufacturer and purchaser shall be agreed with DNV GL.

SECTION 2 DOCUMENTATION REQUIREMENTS

1 Documentation requirements

1.1 General

1.1.1 Documentation for classification shall be in accordance with the Nauticus Production System (NPS) Document Requirement (DocReq). The DocReq is a compilation of all DNV GL's documentation requirements related to plan approval.

The documentation requirements are based on standardised documentation types. Definitions of the documentation types are given in DNVGL-CG-0168.

Guidance note:

For each unit a product model will be generated reflecting the actual components in that will be installed.

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1.1.2 In addition to the documentation indicated in [1.1.1], the documentation requirements of discipline specific standards referenced in this standard shall be provided, avoiding duplication.

1.1.3 For safety systems and essential functions, see [Ch.2 Sec.1 Table 1](#), an FMEA or similar shall be submitted to DNV GL for review.

SECTION 3 SYSTEM AND EQUIPMENT CERTIFICATION

1 General

1.1 System categorisation

A drilling facility will normally consist of drilling systems/equipment that provides essential, important and non-important functions, in addition to containing safety systems (see [Ch.2 Sec.1](#)). All drilling related safety systems and essential/important functions shall fulfil the requirements of this standard. Other recognised standards may only be used provided that they can be clearly shown to provide a comparable or higher level of safety. For non-important systems, the principles of this standard may be applied in the absence of other recognised standards.

1.2 Equipment categorisation

1.2.1 DNV GL uses categorization in order to clearly identify the certification and approval requirements for various equipment.

1.2.2 Categorization of equipment depends on importance for safety and takes operating and environmental conditions into account. Once assigned, the category of equipment refers to the scope of activities required for DNV GL certification and approval, as consistent with the importance of the equipment.

1.2.3 If there is any other equipment which is not defined in the following tables, categorization of the same shall be decided on a case by case basis with prior discussion with DNV GL.

1.2.4 Replacement parts shall be certified in accordance with the requirements of the parts it will be replacing.

1.2.5 Electrical equipment like motors, transformers, converters, etc. are not categorized here. All electrical equipment necessary for operation of components in category I, shall be certified if certification of such equipment is required in DNVGL-OS-D201.

1.2.6 Equipment categorisation for offshore installations or units is as follows:

- I = equipment important for safety and for which a DNV GL certificate is required.
- II = equipment important for safety and for which a works certificate prepared by the manufacturer is accepted.

1.2.7 *Equipment category I*

For equipment category I, the following approval procedure shall be followed:

- design approval, documented by a design verification report (DVR) or type approval certificate. (see [\[3.1\]](#))
- fabrication survey, documented by issue of a product certificate.

Specific requirements:

- pre-production meeting prior to the start of fabrication
- survey during fabrication, as applicable
- witness final functional, pressure and load tests, as applicable
- review of fabrication records.

These requirements are typical and the final extent of DNV GL survey required, will be decided based on:

- complexity, size and previous experience of equipment type;
- manufacturer's QA/QC system,
- manufacturing survey arrangement (MSA) with DNV GL
- type of fabrication methods.

1.2.8 Equipment category II

Equipment of category II is normally acceptable on the basis of a works certificate prepared by the manufacturer. As a minimum, the certificate shall contain the following data:

- equipment specification or data sheet
- operating limitation(s) of the equipment
- statement from the manufacturer to confirm that the equipment has been constructed and manufactured according to recognised methods, codes, and standards
- test records as applicable.

Guidance note:

Independent test certificates or reports for the equipment, or approval certificate for manufacturing system, are also acceptable.

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1.3 Certification and classification principles

1.3.1 General DNV GL certification procedures and requirements are stated in the relevant DNV GL Rules for MOU (see [Sec.1 Table 1](#)).

1.3.2 Categorization of relevant systems and equipment are given in [Table 1](#) to [Table 12](#).

Table 1 Drilling structures

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Drilling structures	Derrick and other drilling tower designs	X	
	Other design	X	
Miscellaneous	Skids and lifting brackets intended for installation lifts		X
	Skids and lifting brackets intended for regular lifts	X	

Table 2 Well control systems

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Blowout prevention equipment	Hydraulic connectors for wellhead and riser	X	
	Ram preventers	X	
	Annular preventers	X	
	Accumulators for subsea stack	X	
	Valves in choke and kill lines	X	
	Gas bleed valves	X	
	Drilling spools / spacer spools	X	
	Clamp	X	
	Test Mandrel		X
	Test stump	X	
	BOP test pump		X
	Valves in drillstring	X	
Blowout prevention, control equipment	Accumulators in control system	X	
	Welded pipes and manifolds ¹⁾	X	
	Unwelded hydraulic piping		X
	Flexible control hoses		X
	Hydraulic hose reel ²⁾	X	
	Control pods	X	
	Acoustic BOP control equipment	X	

Table 2 Well control systems

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Diverter unit, equipment and control equipment	Diverter house with annular valve	X	
	Diverter piping ¹⁾	X	
	Valves in diverter piping	X	
	Diverter handling tool	X	
Choke and kill, equipment and control equipment	Choke manifold (except valves) ¹⁾	X	
	Valves in choke manifold and choke, kill, and booster lines	X	
	All piping to and from choke manifold including choke, kill, and booster lines ¹⁾	X	
	Flexible hoses for choke, kill, and booster lines	X	
	Unions and swivel joints	X	
	Emergency circulation pump – pressure side	X	
Marine riser, equipment and control equipment	Ball joint and flexible joint	X	
	Riser sections including joints	X	
	Support ring for riser tensioning	X	
	Telescopic joint	X	
	Accumulators	X	
1) Certification shall cover system design, manufacture and testing. Requirements to individual piping components; see Table 10 .			
2) The reel itself (equipment not related to BOP control functions) is considered Cat.II.			

Table 3 Heave compensation and tensioning systems

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
General	Hydraulic cylinders and other pressure vessels ¹⁾	X	
	Piping including flexible hoses ²⁾	X	
	Hydro-pneumatic accumulators	X	
	Air compressors and air dryers		X
	Wire ropes		X
	Sheaves	X	
	Anti-recoil valve	X	
	Safety valves ³⁾	X	
Heave compensation	Heave compensator system assembly	X	
	Load carrying parts in compensator system	X	
	Deadline compensator	X	
Tensioning systems	Riser tensioner system assembly	X	
	Top tension/conductor tensioner system assembly	X	
	Load carrying parts in tension system	X	
	Guidelines and podline tensioners/tension winches	X	
	Telescopic arms for tension lines	X	
	Tripsaver skid/trolley	X	
	Air control skid with manifold	X	
	Swivels and goosenecks on tension cylinders ¹⁾	X	
1) See Table 11 .			
2) Certification shall cover system design, manufacture and testing. Requirements to individual piping components; see Table 10 .			
3) Design review of valve and bursting disc is not required. The extent of witnessing of leak-, calibration-, capacity- and qualification-testing to be agreed with DNV GL based on manufacturer's QA/QC system. DNV GL shall normally witness batch qualification tests of bursting discs.			

Table 4 Hoisting and rotating systems

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Conventional hoisting system	Sheaves for crown block and travelling block	X	
	Crown block including support beams	X	
	Guide track and dolly	X	
	Travelling block	X	
	Drawworks including brakes, gear transmissions and foundation	X	
	Deadline anchor	X	
Hydraulic cylinder based hoisting system (ramrig/cylinder hoisting rig)	Lifting cylinders (rams) and valve blocks ¹⁾	X	
	Yoke	X	
	Yoke sheaves	X	
	Sheave clusters including support beams	X	
	Guide track and dolly	X	
	Equalizers	X	
	Deadline anchor	X	
Hoisting equipment in derrick	Drilling hook ²⁾	X	
	Swivel ²⁾	X	
	Links	X	
	Spiders	X	
	Elevators	X	
	Elevator bushing/insert		X
	Drilling line and sand line		X
	Cranes in derrick	X	
Rotating equipment	Rotary table including skid adaptor and driving unit	X	
	Kelly with kelly cock arrangement ²⁾		X
	Master bushing		X
	Kelly bushing ²⁾		X
	Topdrive ²⁾	X	

1) Valves controlling load.
2) Other types of equipment having similar function as the ones listed above are to be equally categorised.

Table 5 BOP and pipe handling

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Pipe and riser handling	Racking arms including possible lifting head	X	
	Manipulator arms	X	
	Guide track and dolly	X	
	Catwalk, Tubular Feeding Machine ¹⁾	X	
	Horizontal to vertical (HTV) equipment	X	
	Riser/pipe handling crane incl. gripper yokes	X	
	Finger board incl. belly board	X	
	Mousehole ²⁾	X	
	Riser Spider and Gimbal	X	
	Riser Handling and Running Tools	X	
BOP and Xmas tree handling	Blowout preventer crane or carrier, skid, guide frame, sea fastening, etc.	X	

Table 5 BOP and pipe handling

Miscellaneous	Power tongs for pipe handling or iron roughneck		X
	Kelly spinner		X
	Power slips		X
<p>1) Accepted as cat. II given the following conditions are met:</p> <ul style="list-style-type: none"> the equipment has only horizontal movement, i.e. cannot be tilted or lifted as part of the pipe handling operation. (It is accepted that a pipe lifter is installed at the end of the equipment, but the pipe lifter shall only lift the end of the pipe up so that other pipe handling equipment can grab and lift the pipe out) failure of any single part of the equipment does not lead to drop or loss of pipe. <p>If the equipment accepted as cat.II is placed on a substructure raising it up from the deck, the substructure is considered cat.I.</p> <p>2) Accepted as cat. II if not powered.</p>			

Table 6 Bulk storage, drilling fluid circulation and mixing and cementing

	Material or equipment	DNV GL approval categories	
		I	II
Bulk storage	Pressurised storage tanks ¹⁾	X	
	Piping for pressurised bulk transport ²⁾		X
	Safety valves ³⁾	X	
	Pumps for bulk transport		X
Drilling fluid circulation and mixing	Drilling fluid pump – pressure side	X	
	Mud manifold (except valves) ²⁾	X	
	Valves in mud manifold	X	
	Pulsation dampers	X	
	Circulation head piping including drilling fluid pump discharge ²⁾	X	
	Mud hoses	X	
	Safety valves ³⁾	X	
	Piping for mixing of drilling fluid, and suction line to drilling fluid pump ²⁾		X
	Centrifugal pumps for mixing / transfer of drilling fluid		X
	Rotary hose assembly	X	
	Kelly cocks	X	
	Drill string		X
	Mud return pipe ²⁾		X
	Shale shaker		X
	Drilling fluid tanks		X
	Degasser including piping to burners or to vents ^{1)and 2)}	X	X
	Chemical mixers		X
	Agitators for drilling fluid		X
Cementing	Cement pump – pressure side	X	
	Cementing head	X	
	Cement manifold (except valves) ²⁾	X	
	Valves in cement manifold	X	
	Pulsation dampers	X	
	Circulation head piping including cement pump discharge ²⁾	X	
	Cement hoses	X	
	Safety valves ³⁾	X	
	Centrifugal pumps for cement mixing / transfer of cement slurry		X
	Piping for mixing of cement, and suction line to cement pump ²⁾		X
<p>1) See Table 11.</p> <p>2) Certification shall cover system design, manufacture and testing. Requirements to individual piping components; see Table 10.</p> <p>3) Design review of valve and bursting disc is not required. The extent of witnessing of leak-, calibration-, capacity- and qualification-testing to be agreed with DNV GL based on manufacturer's QA/QC system. DNV GL shall normally witness batch qualification tests of bursting discs.</p>			

Table 7 Categories for MPD pressure control system

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
General	Accumulators in control system	X	
	Welded pipes and manifolds ¹⁾	X	
	Safety valves ²⁾	X	
	Pulsation dampener	X	
	Control pods	X	
	Mud return line	X	
	LARS (Launch and Recovery) systems	X	
Safety logic unit	Safety logic unit	X	
MPD controller unit ³⁾	MPD controller unit	X	
Well monitoring system	Measuring devices/sensors		X
Dynamic MPD pressure control equipment ³⁾	MPD choke manifold	X	
	Back-pressure pump	X	
	Subsea pump	X	
	Non-return valves in drill string	X	
	Dedicated flow restriction valves	X	
	Annular preventer	X	
	Flexible hoses	X	
Static MPD pressure control equipment ³⁾	Rotating Control Device	X	
	Non-rotating Control Device	X	
	Annular preventer	X	
	Equipment used to isolate internal well pressures	X	
	Riser sections including joints	X	
1) Certification shall cover system design, manufacture and testing. Requirements to individual piping components; see Table 10 . 2) Design review of valve and bursting disc is not required. The extent of witnessing of leak-, calibration-, capacity- and qualification-testing to be agreed with DNV GL based on manufacturer's QA/QC system. DNV GL shall normally witness batch qualification tests of bursting discs. 3) Components of the MPD pressure control system that is not part of a well barrier, nor critical for safety, might be accepted as Cat. II.			

Table 8 Well test systems

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Well test systems	Surface flow tree, incl. valves	X	
	Piping including swivels and flexible hoses ¹⁾	X	
	Pressure vessels and separators ²⁾	X	
	High pressure pumps – pressure side	X	
	Other pumps		X
	Burners	X	
	Flare booms	X	
	Safety valves ³⁾	X	
1) Certification shall cover system design, manufacture and testing. Requirements to individual piping components; see Table 10 . 2) See Table 11 . 3) Design review of valve and bursting disc is not required. The extent of witnessing of leak-, calibration-, capacity- and qualification-testing to be agreed with DNV GL based on manufacturer's QA/QC system. DNV GL shall normally witness batch qualification tests of bursting discs.			

Table 9 Other systems

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Winches	Winches for lifting purposes	X	
	Winches for non-lifting purposes		X
Man riding equipment	Man riding winches, access boards or baskets, etc.	X	
Miscellaneous	Hydraulic power units including pumps and manifolds		X
	Skids or carriers for handling of equipment at height or over moon pool	X	
	Rails for cranes, skids and other equipment		X
	Gear transmissions and brakes for lifting appliances and other critical applications	X	

Table 10 Categories for pipes, fitting and valves in drilling systems

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Piping systems (including spools)	Piping listed in DNV-RP-D101 [3.15.6] Pipe Stress Priority Piping	X	
	All other piping NOT listed in DNV-RP-D101, [3.15.6]		X
Flanges and couplings	Standard flanges and pipe couplings		X
	Non-standard flanges and pipe couplings used in category I piping systems	X	
	Flanges and pipe couplings other than those mentioned above, and flanges and couplings for category II piping system		X
Flexible hoses	Flexible hoses for systems requiring continuous operation and for which failure of flexible hose is considered critical.	X	
Valves	Valve body of welded construction with ANSI rating > 600 lbs	X	
	Valves designed and manufactured in accordance with recognised standards ¹⁾		X
Components of high strength materials ²⁾	Specified yield strength > 345 Mpa (50 000 psi), or tensile strength > 515 Mpa (75 000 psi)	X	
1) Not applicable for category I systems/equipment which do not have a specific reference to this table.			
2) Components made according to recognised standard where the material requirements allow use of high strength steel may be accepted as category II.			

Table 11 Categories for pressure vessels

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Pressure vessels for	Poisonous liquids	X	
	Liquids with flash point below 100°C	X	
	Liquids with temperature above 220°C	X	
	Compressed gases, where pressure × volume ($P \times V$) is above 1.5, where pressure (P) is in bar and volume (V) is in m ³	X	
Other	Pressure vessels that are not included in category I		X
Cylinders	Cylinders for lifting purposes	X	
	Cylinders for non-lifting purposes		X

Table 12 Categories for control systems

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Control systems	Blowout prevention (BOP)	X	
	Diverter	X	
	Choke and Kill	X	
	Emergency transfer/circulation	X	
	Heave compensating	X	
	Main hoisting system	X	
	Riser tension	X	
	Other systems ¹⁾	X	X
1) Categorization will depend on criticality of the system, i.e. whether any potential failures are considered to be critical or not.			

2 Fabrication record

2.1 General

2.1.1 Fabrication record shall be maintained by the manufacturer in a traceable manner, so that relevant information regarding design specifications, materials, fabrication processes, inspection, heat treatment, testing, etc. can be checked.

2.1.2 Fabrication record for category I equipment shall be available for review upon request. The following particulars shall be included, as applicable:

- manufacturer's statement of compliance
- reference to design specifications and drawings
- location of materials and indication of respective material certificates
- welding procedure specifications and qualification test records
- location of weldings indicating where the particular welding procedures have been used
- heat treatment records
- location of non-destructive testing (NDT) indicating where the particular NDT method has been used and its record
- load, pressure and functional test reports
- as-built part numbers and revisions.

3 Documentation deliverables for certification of equipment

3.1 General

3.1.1 The following documentation will normally be issued by DNV GL for equipment and systems covered by certification activities (CMC):

a) *Design verification report, (DVR)*

- DVR will be issued by the design approval responsible for all equipment of category I, unless covered by a valid type approval certificate.
- In addition to each individual equipment, DVRs shall be issued for each system (including control systems) not covered by plan approval.

The DVR shall contain all information needed to be followed up by the surveyor attending fabrication survey and installation of the equipment, and as a minimum include:

- design codes and standards used for design verification
- design specification (e.g. temperature, pressure, SWL, etc.)

- follow-up comments related to e.g. testing, fabrication and installation of the equipment or system.

An approval letter may be issued instead of a DVR, however such a letter shall as a minimum contain the same information as listed above.

Guidance note:

An approval letter will normally be issued for pipe stress- and flexibility analysis reports of complete piping systems. DVRs and Type Approval Certificates will be used for pressure integrity design of individual piping components.

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b) *Product certificate, (PC)*

- PC shall be issued for all category I equipment and systems (including control systems)
- PC will be issued upon successful completion of design verification, fabrication survey and review of final documentation. As stated above, PC cannot be issued if design verification or non-conformances are outstanding.

c) *Survey report*

- Survey report shall be issued for all category I equipment or systems (including control systems) upon satisfactory installation, survey and testing onboard. A survey report may cover several systems or equipment installed. The survey report shall contain clear references to all DVRs and PCs on which the survey report is based, and shall state testing and survey carried out.

3.1.2 The following documentation might be issued by DNV GL for equipment and systems covered by certification activities (CMC), if found necessary:

a) *Report for Incomplete Certification, (RIC)*

- An RIC shall only be issued if the component is delivered prior to issuance of final product certificate (PC). A final PC shall not be issued if there are non-conformances to the equipment or system. The RIC shall be used with detailed description of the non-conformances, and shall always be replaced by a PC when all non-conformances are closed.

APPENDIX A WORKOVER AND WELL INTERVENTION SYSTEMS AND EQUIPMENT

1 General

1.1 Objective

1.1.1 The objectives of this Appendix are to:

- provide an internationally acceptable standard of safety for workover and well intervention facilities by defining minimum requirements for the design, materials, construction, testing and commissioning of such facilities
- serve as a guideline for designers, purchasers and contractors
- serve as a reference document in contractual matters between purchaser and contractor
- specify procedures and requirements for workover and well intervention facilities subject to DNV GL certification and classification.

1.1.2 The requirements of this Appendix are intended to ensure safe design and use of workover and well intervention systems and equipment. This includes requirements for specific items of workover and well intervention equipment and facilities. (E.g. completion, workover and well intervention systems).

1.1.3 The workover and well intervention facilities shall follow the requirements and principles of this standard. However, only parts of [Ch.2 Sec.5](#) where references are given in this Appendix shall apply.

1.2 Scope and application

Systems for which requirements could vary depending on type of installation (fixed, floating, permanently moored, DP operated etc.) are specified under each workover and well intervention system in question.

However, the impact this will have on other non-workover and non-well intervention systems are not included within this standard, see other offshore discipline standards relevant for the system in question.

Guidance note:

E.g. requirements for passive or active fire protection of permanently moored installations compared to that required for DP operated vessels.

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1.3 Control and monitoring

Requirements for control and monitoring are grouped to the extent possible under each system. Systems shall also be in line with the general system requirements found in this Appendix and general requirements for all systems and components in [Ch.2 Sec.1](#) and [Ch.2 Sec.4](#).

1.4 Hydraulic and pneumatic systems

See [Ch.2 Sec.5 \[1.4\]](#).

1.5 Ignition prevention of machinery and electrical equipment

1.5.1 Machinery or electrical installations and other equipment necessary for the workover and well intervention operations (e.g. HPU) which are installed in hazardous areas shall be suitable for the intended purpose and shall comply with the requirements of DNVGL-OS-A101 and DNVGL-OS-D201.

Guidance note:

For mechanical equipment located in an hazardous area, attention should be brought to minimise risk of sparking during normal operation of the equipment, by applying non-sparking materials where relevant (e.g. braking system of draw works), greasing of wheels (e.g. dolly guide wheels) etc.

See DNVGL-OS-A101 Ch.2 Sec.2 [4] for protection of diesel engines for use in zone 2 hazardous area.

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1.5.2 Electrical equipment and instrumentation that shall be operable during extended gas danger shall be

Ex-rated and designed to operate for the intended time interval. Where this is not feasible, means shall be provided to minimise risk of ignition.

Guidance note:

This applies for e.g. EDP/LRP control system located in a safe area. Protection may be provided according to DNVGL-OS-D201 Ch.2 Sec.11 [3.2].

The equipment should be operable for reduced ventilation or cooling when necessary.

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1.6 Emergency stops

See Ch.2 Sec.5 [1.6].

1.7 Automatic start of pumps

See Ch.2 Sec.5 [1.7].

2 Well intervention related structures

2.1 General

See Ch.2 Sec.5 [2.1].

2.2 Well intervention structures

See Ch.2 Sec.5 [2.2].

2.3 Drill floor

See Ch.2 Sec.5 [2.3].

2.4 Substructure

See Ch.2 Sec.5 [2.4].

2.5 Support structure for drilling or well testing

See Ch.2 Sec.5 [2.5].

2.6 Lifting of equipment

See Ch.2 Sec.5 [2.6].

3 Well control systems

3.1 General

3.1.1 Well control systems normally comprise the following systems:

Riserless systems:

- pressure control head (incl. stuffing box, grease injection)
- grease injection
- lubricator section
- blowout preventer section (EDP, LRP)
- choke and kill system

Workover riser in open-sea systems:

- surface flow tree
- riser system
- blowout preventer section (EDP, LRP)

- choke and kill system

Workover riser, marine riser and drilling BOP systems:

- drilling well control system (ref. [Ch.2 Sec.5 \[3.1\]](#))
- surface flow tree
- workover riser or landing string (run through marine riser system)
- subsea test tree (run inside BOP).

3.1.2 The well control systems/components as specified in [\[3\]](#) are categorized as either safety systems or essential functions.

Guidance note:

This implies that the workover and well intervention system shall be "fail-to safe".

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3.1.3 No single failure shall lead to an overall system failure or loss of well control.

3.1.4 A double barrier philosophy should be used when designing the system.

3.1.5 The well intervention blowout preventer section shall in general consist of the following as a minimum:

- EDP
- LRP
- Christmas tree connector
- necessary control equipment

Guidance note:

The EDP stack typically consists of:

- emergency riser connector
- riser isolation (retainer) valve
- annulus isolation (retainer) valve
- single isolation between main bore and annulus bore

The LRP stack typically consists of:

- two isolation valves in series between main bore and environment
- two isolation valves in series between annulus bore and environment
- two isolation valves in series between main bore and annulus bore (seen from below, i.e. Christmas tree)
- one shear ram in bores used for coiled tubing or wire line

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For requirements to drilling BOP see [Ch.2 Sec.5 \[3.1.10\]](#).

3.1.6 Design of well intervention riser systems and components shall be in accordance with [Ch.2 Sec.1 \[9\]](#). Design Calculations.

Guidance note:

E.g. *ISO 13628-7* for mechanical components, unless covered by applied code or standard.

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3.2 Blowout prevention

3.2.1 Blowout preventer stack (EDP, LRP)

- 1 The blowout preventer stack (EDP,LRP) shall be designed to enable fluid and gas to be conducted out of the system, and to enable fluid to be pumped into the system.
- 2 Two valves shall be installed in series close to the blowout preventer stack for each of the choke and kill lines (annulus line). The valves shall be provided with remote control and shall be of the fail-safe-close type. The valves shall be located so that they are protected against damage from falling objects.

- .3 The shear rams shall be capable of shearing the thickest section wire line, coiled tubing, tool, slack wire or landing string shear sub specified for use with the blowout preventers. If objects cannot be sheared, either 2 shear rams must be installed, or lifting or lowering of main hoisting system shall be possible in all operational modes, including emergency operation.

Guidance note:

For long sections (e.g. tubing, liner, perforating guns, etc.) that prove unfeasible to either cut or lift/lower, a mechanical release device (i.e. drop table) should be provided in the rotary area.

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- .4 Pipe rams shall be designed for any hang-off loads to which they may be subjected.

Guidance note:

If slip rams are used, the slip ram should be designed for any hang-off loads.

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- .5 Valves and rams shall be able to open and close at maximum pressure and maximum flow.
 .6 The blowout preventer section body shall be designed for maximum operational loads, such as tension, bending moments, internal and external pressures and environmental loads.
 .7 Shear or blind rams and pipe rams shall be equipped with mechanical locking devices.
 .8 Flexible lines shall be in accordance with [Ch.2 Sec.3 \[2.3\]](#) or ISO 13628-7.

3.2.2 Riser and Christmas tree connector

- .1 Emergency operation of the riser connector, EDP or LMRP shall be available from an additional location to the place of normal operation. The location of the additional control shall be selected such that at least one control point is likely to be accessible in the event of an emergency.
 .2 Hydraulically operated Christmas tree and riser (EDP or LMRP) connectors shall have redundant mechanisms for unlock and disconnect. The secondary unlock mechanism may be hydraulic or mechanical but shall operate independently of the primary unlocking mechanism.
 .3 The maximum tilt angle of riser (EDP or LMRP) connector for mechanical freeing shall be stated.
 .4 Activation of riser connector (EDP or LMRP), shear ram and Christmas tree connector shall be protected with a key lock, protective cover or interlock within the control system.

3.2.3 Control and monitoring

- .1 The workover and well intervention control system shall be provided with at least two mutually independent control panels, i.e. directly connected to the control system, and not connected in series. The control panels shall include controls for at least, but not limited to:

- close or open of all rams, valves, and connectors in the riser system.

For subsea blowout preventer sections for floating installations, the following additional controls shall be included:

- operational disconnect of riser connector (EDP or LMRP)
- emergency disconnect sequence.

- .2 The well control system should typically be able to perform the following:

Process shutdown:

- isolating the well control system from the vessel process plant

Emergency shutdown:

- closing of barrier elements (leaving the well in a safe state)

Emergency disconnect:

- closing of barrier elements (leaving the well in a safe state)
- disconnection of riser connector, EDP or LMRP.

- .3 For electrical or computer based subsea systems, activation of the emergency disconnect shall initiate and complete disconnection in the correct sequence.
- .4 Design of emergency disconnect system shall take into account the required total time to execute the sequence.
- .5 One control panel shall be located at the main control station for workover and well intervention operations.
- .6 A second control panel shall be located at a suitable distance from the main control station, and shall be arranged for easy access.
- .7 Control panels shall give clear indication of blowout preventer status (i.e. open or closed), and shall indicate available pressure for the various functions and operations.
- .8 Control panels shall be fitted with visual and audible alarm signals for:
 - low accumulator pressure
 - loss of power supply
 - low levels in the control fluid storage tanks.
- .9 When the system is started or reset, normal operation shall be resumed automatically.

Guidance note:

E.g. regulators should not lose their set point.

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- .10 For hydraulic systems, the main unit of the control system, including the pilot valves, shall be situated so as to be shielded from the drill floor or cellar deck. The unit shall be easily accessible both from the drill floor, and also from the outside without requiring entry via the drill floor or the cellar deck. The main unit shall be designed to withstand any single failure.
- .11 For electrical or computer based systems, two mutually independent systems shall be installed. This independence shall include all design events.
- .12 The closing unit accumulators shall as a minimum meet the capacity requirements of ISO 13628-7 Section 5.5.7 or equivalent.
- .13 When subsea BOP/LRP systems are fitted with a secondary disconnection system in the event of failure of main system during an uncontrolled well situation, the following shall apply:
 - it shall be possible to activate the system from a portable unit
 - the secondary disconnection system shall be independent of the main system, including accumulator capacity
 - the system shall be able to perform BOP closure, cutting of coiled tubing, wireline, landing string shear sub, and disconnection to enable the unit to move off to a safe location.
- .14 When installed, the secondary disconnection system shall be fitted with a dedicated closing subsea accumulator unit. Such accumulator unit shall have sufficient capacity (volume and pressure), with pumps inoperative, to close-open-close one pipe ram preventer/isolation valve, close shear rams and open riser connector (EDP/LMRP), in the specified sequence order.
- .15 The well intervention control system shall be designed in such a way that each blowout preventer response time is within acceptable limits according to recognised codes and standards.

Guidance note:

For surface BOPs, this is normally within 30 s (from activation until close function is completed), up to 45 s for annular preventers.

For subsea BOPs and LRPs, this is normally within 45 s for rams, 60 s for annular preventers.

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- .16 To prevent inadvertent operation, activation of all functions shall be arranged as required in [Ch.2 Sec.1 \[5.1\]](#).
Additionally, for floating installations, the activation devices for riser disconnection and shear rams shall have additional protection against inadvertent operation.

Guidance note:

E.g. hinged covers in front of activation buttons.

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- .17 Electro-hydraulic and multiplex (MUX) EDP/LRP systems shall be provided with two independent pods.
 .18 As long as redundancy is maintained within the umbilical and the system is fail-safe-close, only one umbilical is required.

3.3 Diverter

If applicable, see [Ch.2 Sec.5 \[3.3\]](#) for requirements.

3.4 Choke and kill

3.4.1 See [Ch.2 Sec.5 \[3.4\]](#) for requirements.

Guidance note:

Deviations from some of these referenced requirements might be accepted for choke and kill systems covered by this Appendix, if it can be documented that the required safety level is ensured by the provided functionality. This will be considered on a case-by-case basis.

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3.4.2 If the riser annulus line is intended to be used for killing operations, it shall be sized accordingly (i.e. pump rate and pressure).

3.5 Workover riser system

3.5.1 Workover riser systems shall be designed in accordance with ISO 13628-7 *Design and operation of subsea production systems - Part 7 Completion/workover riser systems*.

Guidance note:

See [Ch.1 Sec.1 \[3\]](#) for guidance on deviations/equivalent solutions and other details.

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3.5.2 Workover risers shall be designed to withstand applicable combined design loads for the application in the required water depth.

Guidance note:

Relevant loads to evaluate include:

- waves
- current
- riser tensional loads and load variations
- vessel motion
- circulation fluid specific gravity (SG)
- collapse pressure
- internal pressure
- handling loads.

See ISO 13628-7, DNV-OS-F201 or equivalent for further guidance.

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3.5.3 Riser system design shall evaluate the need for deliberately introducing weak links in the system.

Guidance note:

Weak links are introduced to protect components against accidental loads, i.e. drive-off, drift-off or tensioner system failure.

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4 Heave compensation and tensioning system

See applicable parts of [Ch.2 Sec.5 \[4\]](#).

5 Hoisting systems

See applicable parts of [Ch.2 Sec.5 \[5\]](#).

6 Handling equipment

See applicable parts of [Ch.2 Sec.5 \[6\]](#).

7 Bulk storage, fluid circulation and mixing, cementing and well stimulation fluids

See applicable parts of [Ch.2 Sec.5 \[7\]](#).

8 Well testing and associated well control system

See applicable parts of [Ch.2 Sec.5 \[9\]](#).

9 Man rider equipment

See applicable parts of [Ch.2 Sec.5 \[10\]](#).

10 Other systems

See applicable parts of [Ch.2 Sec.5 \[11\]](#).

11 Manufacture, workmanship and testing

See applicable parts of [Ch.2 Sec.6](#).

12 Certification and classification

12.1 Class designation

Offshore units and installations fitted with well intervention plants which have been designed, constructed and installed in accordance with the requirements of this Appendix A under the supervision of DNV GL will be entitled to the class notation **WELL-1** or **WELL-2**.

Guidance note:

For further clarifications of class scope see Rules for Drilling and Support Units. See DNVGL-SI-0166 for **WELL(N)**.

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12.2 System and equipment certification

12.2.1 System and equipment certification shall follow principles given in [Ch.3](#).

12.2.2 Categorization of relevant workover and well intervention systems and equipment are given in [Table 1](#).

12.2.3 Categorization of systems and equipment not covered by [Table 1](#), but described in this appendix chapters [\[2\]](#) to [\[10\]](#), are given in [Ch.3 Sec.3](#).

Table 1 Categories for workover and well intervention systems and equipment

	Material or equipment	DNV GL approval categories	
		I	II
Wire line	Wire line unit including power pack		X
	Wire line BOP	X	
	Grease injection skid for braided line and stuffing box for slick line	X	
	Line pressure control head	X	
	Wire line winch		X
Coiled tubing	Coiled tubing unit including power pack		X
	Coiled tubing BOP	X	
	Coiled tubing reel		X
	Injector head		X
	Coiled tubing stripper	X	

Table 1 Categories for workover and well intervention systems and equipment (Continued)

	<i>Material or equipment</i>	<i>DNV GL approval categories</i>	
		<i>I</i>	<i>II</i>
Workover riser (mono or dual bore)	Riser sections including joints	X	
	Telescopic joint	X	
	Ball joint and flexible joint	X	
	Swivel	X	
	Support ring for riser tensioning	X	
Blowout prevention equipment	Emergency Disconnect Package (EDP) ¹⁾	X	
	Lower Riser Package (LRP) ¹⁾	X	
General systems and equipment	Surface flow tree	X	
	Lubricator valve	X	
	Subsea test tree	X	
	Tension frame and/or bails	X	
	Moonpool doors	X	
	Cursor frame, Moonpool guide frame	X	
	Lifting tower and well-servicing derrick	X	
	Lifting equipment	X	
	High pressure pumping facilities (cement, well stimulation fluids, nitrogen, chemical injection)	X	
	Flexible hoses for choke and kill operations and chemical injection	X	
	Hydrocarbon handling	X	
	Workover control system	X	
	Umbilicals for subsea controls		X
1) See Ch.3 Sec.3 Table 2.			



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