DNV·GL

OFFSHORE STANDARDS

DNVGL-OS-E101 Edition January 2018

Drilling facilities

DNV GL AS

FOREWORD

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

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

CHANGES – CURRENT

This document supersedes the July 2015 edition of DNVGL-OS-E101.

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

Changes January 2018, entering into force 1 July 2018

All parts of the standard has been revised, re-structured and updated. Main changes are provided here:

Topic	*Reference*	*Description*
General	Ch.1 Sec.1 [2]	Updated and new definitions.
	Ch.1 Sec.1 [3]	Clarification on how normative references shall be applied, with updated reference list and alternative references.
	Ch.1 Sec.1 [4]	Introduction of informative references, for guidance and information.
Barrier management	Ch.2 Sec.1 [2]	Introduction of barrier management as the governing safety philosophy. Realized in the standard by a technical operative barrier and a technical safety barrier.
	Ch.2 Sec.1 [3]	Drilling systems are divided into operative systems realizing operative barriers or safety systems realizing safety barriers. Performance requirements are provided to operative and safety systems. For operative systems, performance requirements depend on whether a function is categorised as essential, important or less-important.
	Ch.2 Sec.5 [2]	New subsection addressing general hazardous events.
	Ch.2 Sec.6 and Ch.2 Sec.7	All subsections includes hazardous events and barrier functions for the specific drilling systems/equipment. Barrier functions are categorised and accompanying performance requirements are provided. Applicability of requirements is clarified by the separation of operative barrier requirements from safety barrier requirements, as these barriers are required to be independent.
General design requirements	Ch.2 Sec.2	Restructure and general update of material requirements. Clarifying material requirements to various applications.
	Ch.2 Sec.2 [4]	New subsection for high-pressure high-temperature (HPHT) applications.
	Ch.2 Sec.3	Restructure and general update of piping requirements.
	Ch.2 Sec.3 [3.6]	New subsection for glass-reinforced plastic (GRP) piping.
	Ch.2 Sec.4	Now including relevant parts from Ch.2 Sec.1 and Ch.2 Sec.5 in July 2015-edition.
	Ch.2 Sec.5	Ch.2 Sec.5 in July 2015-edition has been split into Ch.2 Sec.5, Sec.6 and Sec.7. Sec.5 now contains general requirements to drilling systems. Requirements to specific drilling systems are found in Sec.6 and Sec.7.
	Ch.2 Sec.6	New section covering hoisting, rotating and handling systems (previously covered by Ch.2 Sec.5 in July 2015-edition).
	Ch.2 Sec.6 [2]	New requirements for capacity rating of the drilling hoisting system. Brake requirements are clarified.

Topic	Reference	Description
	Ch.2 Sec.6 [5]	Clarified loads to be considered and factors to be included in calculations for manriding equipment.
	Ch.2 Sec.7	New section covering hoisting, rotating and handling systems (previously covered by Ch.2 Sec.5 in July 2015-edition).
	Ch.2 Sec.7 [1]	New subsection on well barriers, including alternatives on how these may be arranged.
	Ch.2 Sec.7 [3]	Drilling fluid circulation and cementing systems provide well influx prevention (WIP). Requirements are updated and managed pressure drilling (MPD) is included with updated structure and requirements.
	Ch.2 Sec.7 [4]	Blowout preventer (BOP) systems provide well influx management (WIM) and well shut-in and disconnect (WSD). Requirements are updated and re-structured and alternatives for how to arrange systems and functionality under WIM are provided. Requirement applicability for WIM/WSD is clarified for each subsection, as are applicability for surface BOPs/subsea BOPs. Requirements to BOP test systems is included.
	Ch.2 Sec.7 [7]	Clarifying general requirements to drilling risers and specific requirements to surface drilling risers.
Test requirements	Ch.2 Sec.8	Requirements for manufacturing, workmanship and testing have been updated. The required tests are listed in [3], while [4] specifies when a specific test shall be performed. Provisions for flexibility within the testing regime is provided.
	Ch.2 Sec.8 [3]	Requirements to NDT procedure, extent and acceptance criteria is updated. Requirements to function and failure testing is explicitly listed for clarification.
	Ch.2 Sec.8 [4]	Required testing is divided into [4.1] *Testing before system/equipment delivery* and [4.2] *Onboard testing*.
	Ch.2 Sec.8 [4.1]	Scope for component/hardware tests and system tests to be performed before system/ equipment delivery is clarified. Procedure if scope will be transferred to Onboard testing is included.
	Ch.2 Sec.8 [4.2]	Scope for commissioning and system integration tests to be performed onboard is clarified.
Simulator-based testing	Ch.2 Sec.8 [4.1]	Requirements to when and how simulator-based testing shall be performed is included. Details are provided for simulator test setup, simulator framework, simulator accuracy and simulator validation.
	Ch.3 Sec.2 [3.1.4.2]	Including documentation requirements for simulator-based testing.
General classification/ certification requirements	Ch.3 Sec.1	Requirement to DNV GL attendance where FMEA is required by the standard. Clarification on attendance for design validation/verification testing.
	Ch.3 Sec.1 [3]	New subsection on voluntary services.
	Ch.3 Sec.2	Updated section on documentation requirements for various applications.
	Ch.3 Sec.3	Updated certification requirements and final deliverables.

Editorial corrections

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

CONTENTS

Contents

CHAPTER 1 INTRODUCTION

SECTION 1 INTRODUCTION

1 General

1.1 Introduction

1.1.1 This offshore standard contains principles, technical requirements and guidance on design, manufacturing, installation and testing of drilling facilities.

Guidance note:

Principles, technical requirements and guidance on design, manufacturing, installation and testing of workover and well intervention facilities are provided in App.A.

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1.1.2 The standard is provided as a facilities standard and is supplementary to other discipline specific standards.

Guidance note:

Discipline standards for structures, electrical, materials, etc. are specified in [3].

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1.2 Objective

The objectives of this standard are to:

— provide an internationally acceptable standard of safety and reliability for drilling facilities, by defining minimum requirements for design, manufacturing, installation and testing of such facilities
— serve as a reference document in contractual matters
— serve as a guideline for designers, manufacturers, purchasers, owners, contractors and operators
— specify requirements for drilling facilities subject to DNV GL certification and classification.

1.3 Scope

1.3.1 The standard covers drilling systems and equipment located both surface and subsea, including wellhead connectors, but not wellhead or elements located below wellhead.

1.3.2 The prescriptive requirements in the standard are the results of generic hazard identification and barrier analysis based on existing technology and operations.

Guidance note:

For complex or non-standard applications, see DNVGL-OS-A101 Ch.2 Sec.1 [2.1.6].

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1.3.3 Prescriptive requirements are not intended to inhibit the development and application of new technology and operations, and available technological and technical improvements at the time of application should be taken into account.

Introduction of novel technology or designs shall be preceded by a recognised qualification process.

Guidance note:

E.g. as described in DNVGL-RP-A203.

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1.3.4 Alternative solutions, if clearly proven to provide an equivalent or higher safety level than required in this standard, may be considered to comply with this standard.

1.4 Application

1.4.1 The standard has been written for general world-wide application.

Guidance note 1:

Local governmental regulations might include requirements in excess of the provisions of this standard.

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Guidance note 2:

For cold climate operations, see DNVGL-OS-A201.

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1.4.2 The standard is applicable to drilling facilities located on mobile offshore drilling units (MODUs) and on offshore installations (OIs) of various types.

Guidance note:

The standard should be applied from concept design, manufacturing, through to final installation and testing, including major modifications.

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1.4.3 Requirements provided by this standard apply to all systems and equipment, whether permanently or temporarily installed.

Guidance note:

See DNV-OTG-05 for guidance on temporarily installed equipment.

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1.5 Structure

This standard is divided into three chapters:

— Ch.1: General information, scope, definitions and references.
— Ch.2: Technical provisions, including general requirements in Ch.2 Sec.1 to Ch.2 Sec.5, requirements to specific systems and equipment in Ch.2 Sec.6 and Ch.2 Sec.7, and testing requirements in Ch.2 Sec.8.
— Ch.3: Specific procedures and requirements applicable for certification and classification of drilling facilities.

The standard has one appendix:

— App.A: Workover and well intervention facilities.

1.6 Deviation from the requirements

Any modifications, deviations or exceptions to the requirements of this standard shall be documented and agreed between all contracting parties.

2 Definitions and abbreviations

2.1 Verbal forms

Table 1 Verbal forms

Term	*Definition*
shall	verbal form used to indicate requirements strictly to be followed in order to conform to this standard
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 this standard
agreement or by agreement	unless otherwise indicated, agreed in writing between contracting parties

2.2 Terms and definitions

Table 2 Terms and 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---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
barrier	technical, operational and organizational elements which are intended, individually or collectively, to: — identify conditions that might lead to, or — reduce the possibility for, or — limit consequences of, an error, hazard or incident
barrier element	technical, operational or organizational measures or solutions which play a part in realizing a barrier function
barrier function	the task or role of a barrier, e.g. preventing unintentional well influx/leaks/excessive loads/dropped objects, mitigating the consequence of dropped load, etc.
bolted connection	joining of components through use of bolting for pressure retaining and structural/mechanical applications
bolting	bolts, studs, screws, nuts, washers
choke/kill line valve	valve connected to, and part of the BOP stack that controls flow to the choke and kill manifold

Term	*Definition*
contracting parties	parties who need to adhere to a formal written agreement (contract)
control station	general term for any location space where essential and important control functions and/or safety functions are performed **Guidance note:** Typical examples are drilling control station (driller's cabin), toolpusher's office, bridge, etc. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
control unit	entity of hardware and software
custom designed bolts	bolts designed for a specific application and not in accordance with a normative reference, (see [3])
deep water	water depth exceeding 600 meters
design pressure	the maximum pressure for which the system/equipment is designed The design pressure cannot be higher than the MAWP.
drilling facilities	drilling systems and equipment required for drilling operations and well testing onshore and offshore
end termination	the part of the hose assembly which connects to the ends of the hose body, (normally clamped or bonded to hose body)
equipment	mechanical components of which the drilling systems covered by this standard consist
equipment under control	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	a function, failure of which could create an immediate danger to personnel, environment or the MODU/OI
fail to safe state	component or system that automatically goes to, or remains in, a predefined safe position when a specific failure or event occurs
failure	loss of ability to perform as required
field instrumentation	all instrumentation that forms an integral part of a process segment to maintain a function The field instrumentation includes: — 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) 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.
flexible hose	an assembly consisting of hose body, end termination and end connection
hazardous area	all areas in which a flammable or explosive gas and air mixtures may be expected in quantities such that special precautions for the construction, installation and use of electrical equipment and machinery are required
hazardous event	event that could be life-threatening for personnel, or could create significant damage to the environment or property
hose assembly	hose body with end termination

Term	*Definition*
hose design family	hose assemblies of different internal diameter and working pressure with the same number of reinforcing layers and utilizing the same method of end termination attachment and designed to the same design methodology and maximum allowable stress criteria
high pressure	pressures above 207 bar (3000 psi)
High-Pressure High-Temperature (HPHT) well	a well with anticipated shut-in pressure exceeding 1034 bar (15 000 psi) or a flowing temperature at seafloor exceeding 177 °C (350°F)
important function	a function, failure of which could impair the safety of personnel, environment or the installation, but it would not create an immediate danger
independent systems	systems are independent when a single failure occurring in either of the systems, including their controls, monitoring and utilites, has no consequences for the maintained operation of the other system(s)
indications	the visual presentation of equipment values or system status to a user
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 devises or keys that ensure that operations (e.g. opening and closing of valves) are carried out in the right sequence
less-important function	function whose failure or loss can not create a danger to personnel, environment or the MODU/OI
lifting appliance	machine or appliance used for the purpose of lifting goods, materials or personnel **Guidance note:** Lifting implies vertical movement. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
load rating	maximum operating load, both static and dynamic, which may be applied to the system/ component
managed pressure drilling	an adaptive drilling process used to more precisely control the annular pressure profile throughout the wellbore
maximum allowable working pressure (MAWP)	maximum pressure which a system/component may be exposed to **Guidance note:** MAWP value is affected by operating temperature and MAWP should therefore be specified with an associated temperature. MAWP value does not remain constant throughout the lifespan of the system/component, as the value reduces with reduced wall thickness, e.g. due to wear (erosion), fatigue and corrosion. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e--- The set point of PSVs shall not exceed this pressure.
maximum design temperature	the highest specified temperature for which the component/system is designed The highest service temperature is the highest temperature the component/system can be exposed to.
maximum operating pressure	maximum operating pressure of a system/component Maximum operating pressure shall not exceed the design pressure.

Term	*Definition*
maximum restoration time	the longest 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	lowest specified temperature for which the component/system is designed Lowest service temperature; the lowest temperature the component/system can be exposed to while operational.
mobile offshore drilling unit	a buoyant construction engaged in offshore drilling operations, not intended for service at one particular offshore location, and which can be relocated without major dismantling or modification
multiplex 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
offshore installation	a buoyant or non-buoyant construction engaged in offshore drilling operations and which is designed and intended for permanent installation at a location
operating conditions	conditions wherein an offshore installation or a MODU 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
operative barrier	barrier provided by an operative system
operative system	system required in order to perform the drilling operations as intended
operative well barrier (primary well barrier)	a single or multiple gradient fluid column, with or without active pump support and/or a mechanical device that provide the ability to control pressure and prevent unintentional flow from the well
pipe	a pressure-tight cylinder used to convey a fluid or transmit a fluid pressure
pipe fitting	type of piping component. Includes bends, elbows, end connections (such as flanges, unions and couplings), blocks, swivels, crosses, tees, ells, reducers, o-lets, expansion elements, etc.
piping	assembly of piping components and piping supports
piping component	mechanical element suitable for joining or assembly into pressure-tight fluid-containing piping systems Piping components include pipes, pipe fittings, valves and flexible hoses.
piping system	interconnected piping, subject to the same set(s) of design conditions
pressure-containing component	component exposed to fluids, failure of which might result in release of fluids to the environment
pressure-controlling component	component controlling or regulating movement of pressurized fluids
pressure-retaining component	component not exposed to fluids, failure of which might result in release of fluids to the environment
primary structural member/mechanical component	structural member/equipment component which provides an important function for the overall integrity of the structure/equipment
process	the result of the action done by the equipment under control

Term	Definition
process segment	a collection of mechanical equipment with its related field instrumentation, e.g. a machinery or a piping system
redundancy	duplication of components or functions of a system with the intention of increasing reliability of the system
redundant system	system where one or more components and/or functions are duplicated **Guidance note:** Required level of redundancy, i.e. components and/or functions required to be duplicated, is provided in this standard. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
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	maximum allowable mass to be lifted
safety barrier	barrier provided by a safety system
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 system	systems, including required control/monitoring and 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 — WSD/Diverter including control system — Other safety systems for drilling systems/equipment (e.g. emergency stop, overload protection, etc.). ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
safety well barrier (secondary well barrier)	one or more mechanical devices for shut-in of the well and disconnect of riser (for floaters) upon loss of operative well barrier(s)
secondary structural member/mechanical component	structural member/mechanical component which provides a less-important function, and where failure will be without significant consequence to the overall integrity of the structure/ equipment

Term	Definition
software dependent system/equipment providing essential or safety functions	system/equipment where essential or safety functions cannot be executed without software **Guidance note:** If back-up (e.g. manual or hardwired) is available for execution of all essential and safety functions, the system/equipment is not considered software dependent. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
special area	area of structure/equipment; structural member/mechanical component which provides a safety function or an essential function for the overall integrity of the structure/equipment Member/component which is subject to a stress condition that may increase the probability of a brittle fracture (e.g. stress concentrations), or which is non-redundant.
specified maximum stop distance	a distance specified by drilling hoisting system designer Calculated using the documented worst case scenario, i.e. considering the most critical combination of translational and rotational motions using minimum allowed braking capacity, and including the time delay from emergency braking system is activated and until it is fully engaged.
survival condition	condition during which a MODU/OI may be subjected to the most severe environmental loading for which the MODU/OI is designed Drilling or similar operations may have been discontinued due to the severity of the environmental loading.
temporary equipment	equipment intended for use on MODUs/OIs for a limited time
transit condition	all MODU movements from one geographical location to another
tube/tubing	see pipe
uninterruptible power supply	device supplying output power in some limited time period after loss of input power with no interruption of the output power
user	a human being that will use a system or device, e.g. captain, navigator, engineer, radio operator, stock-keeper, etc.
user input device	device from which a user may issue an input including handles, buttons, switches, keyboard, joystick, pointing device, voice sensor and other control actuators
visual display unit	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 unintentional flow from the well
well barrier element	see barrier element
wetted component	any component exposed to wellbore fluids either by design or because of internal seal leakage

2.3 Abbreviations

Abbreviations as shown in Table 3 apply to this standard.

Table 3 Abbreviations

Abbreviations	*Description*
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BOP	blowout preventer
BSR	blind shear ram
CRT	cathode ray tube
CSR	casing shear ram
DFF	design fatigue factor
DP	dynamic position
DVR	design verification report
ECCU	electronic central control unit
EDP	emergency disconnect package
EDS	emergency disconnect sequence
EN	European Standard
ESD	emergency shutdown
EUC	equipment under control
EWT	extended well testing
FEM	Fédération Européenne de la Manutention
FMEA	failure mode and effect analysis
F&G	fire and gas
HAZID	hazard identification
HAZOP	hazard operability
HPHT	high-pressure high-temperature
HPU	hydraulic power unit
HV10	vickers hardness number
IEC	International Electrotechnical Commission
IMO	International Maritime Organisation
ISO	International Organisation for Standardisation
ITP	inspection and test plan
LCD	liquid crystal display

Abbreviations	*Description*
LED	light emitting diode
LMRP	lower marine riser package
LRP	lower riser package
LTB	locked-to-bottom
MDT	minimum design temperature
MGS	mud/gas separator
MODU	mobile offshore drilling unit
MPD	managed pressure drilling
MT	magnetic particle testing
MUX	multiplex
NACE	National Association of Corrosion Engineers
NDE	normally de-energised
NDT	non-destructive testing
NE	normally energised
OI	offshore installation
PC	product certificate
PCV	pressure control valve
PSD	process shutdown
PSV	pressure safety valve
PT	penetrant testing
PWHT	post weld heat treatment
RCD	rotating control device
RIC	report for incomplete certification
RPM	revolutions per minute
RT	radiographic testing
SG	specific gravity
SWL	safe working load
TA	type approval
TEMA	tubular exchange manufacturers association
UID	user input device
UPS	uninterruptible power supply
UT	ultrasonic testing
VDU	visual display unit

Abbreviations	*Description*
VT	visual testing
WIM	well influx management
WIP	well influx prevention
WPS	welding procedure specification
WPT	welding production test
WPQT	welding procedure qualification test
WSD	well shut-in and disconnect
XT	christmas tree

3 Normative references

3.1 General

3.1.1 The standard includes references to other DNV GL documents and to internationally recognised codes and standards, which shall be used in conjunction with the requirements provided in this standard.

These normative references are provided in Table 4 and Table 5.

All applicable requirements for the system or equipment in question arising from the normative reference shall apply.

Guidance note:

With reference to [1.3.4], other codes and standards may be applied, provided that such alternative codes/standards can be clearly proven to provide an equivalent or higher safety level.

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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 latest issue of the normative reference valid on the date of contract signed between the contracting parties shall be used, unless otherwise specified in the contract.

3.1.4 In any instance of conflict between specific requirements of a reference standard and this standard, the requirements of this standard shall apply.

Table 4 DNV GL discipline specific standards

Document code	*Title*
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-C401	Fabrication and testing of offshore structures
DNVGL-OS-D101	Marine and machinery systems and equipment

Document code	*Title*
DNVGL-OS-D201	Electrical installations
DNVGL-OS-D202	Automation, safety and telecommunication systems
DNVGL-OS-D301	Fire protection

Table 5 International and national references

System/ equipment	*Reference no.*	*Title*	*Alternative reference no.*	*Title*
Accumulators[1)]	ISO 9809	Gas cylinders - Refillable seamless steel gas cylinders	EN 14359	Gas-loaded accumulators for fluid power applications
			ISO 11120	Gas cylinders - Refillable seamless steel tubes of water capacity between 150l to 3000l
	ISO 11119	Gas cylinders of composite construction		
Boilers	ASME Boiler and Pressure Vessel Code	Section I, Power Boilers	ASME Boiler and Pressure Vessel Code	Section IV, Heating Boilers
			DNVGL-RU-SHIP Pt.4 Ch.7	Pressure equipment
			EN 12952	Water-tube boilers and auxiliary installations
			EN 12953	Shell boilers
Bolting	API Spec 20E	Alloy and Carbon Steel Bolting for Use in the Petroleum and Natural Gas Industries		
	API Spec 20F	Corrosion Resistant Bolting for Use in the Petroleum and Natural Gas Industries		
	ASTM A193	Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications		
	ASTM A194	Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both		
	ASTM A320	Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service		

System/ equipment	*Reference no.*	*Title*	*Alternative reference no.*	*Title*
	ASTM A540	Standard Specification for Alloy-Steel Bolting for Special Applications		
	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		
BOPs	API Spec 6A	Wellhead and Christmas Tree Equipment	ISO 10423	Petroleum and natural gas industries - Drilling and production equipment - Specification for valves, wellhead and Christmas tree equipment
	API Spec 16A	Drill Through Equipment	ISO 13533	Petroleum and natural gas industries-Drilling and production equipment-Drill through equipment
	API Spec 16D	Control Systems for Drilling Well Control Equipment		
	API Spec 17D	Subsea Wellhead and Christmas Tree Equipment	ISO 13628-4	Subsea wellhead and tree equipment
	API Standard 53	Blowout Prevention Equipment Systems for Drilling Operations		
Choke and kill systems	API Spec 16C	Choke and Kill Equipment		
Corrosion - hydrogen sulphide	NACE MR-0175	Petroleum and natural gas industries - Materials for use in H2S-containing environments in oil and gas production	ISO 15156	Petroleum and natural gas industries - Materials for use in H2S-containing environments in oil and gas production
Derrick	API Spec 4F	Drilling and Well Servicing Structures	ISO 13626	Petroleum and natural gas industries - Drilling and production equipment - Drilling and well-servicing structures
Diverter systems	API RP 64	Diverter Systems Equipment and Operations		
	API Spec 6D	Specification for Pipeline Valves	ISO 14313	Petroleum and natural gas industries - Pipeline transportation systems Pipeline valves

System/ equipment	*Reference no.*	*Title*	*Alternative reference no.*	*Title*
Drilling equipment	API Spec 7K	Drilling and Well Servicing Equipment	ISO 14693	Petroleum and natural gas industries — Drilling and well-servicing equipment
	API Spec 8C	Drilling and Production Hoisting Equipment (PSL1 and PSL2)	ISO 13535	Petroleum and natural gas industries - Drilling and production equipment - Hoisting equipment
	API Spec 9A	Wire Rope	ISO 10425	Steel Wire Ropes for the Petroleum and Natural Gas Industries-Minimum
Drilling riser systems	API Spec 16A	Drill Trough Equipment	ISO 13533	Petroleum and natural gas industries-Drilling and production equipment-Drill through equipment
	API Spec 16F	Specification for Marine Drilling Riser Equipment	ISO 13624-1	Petroleum and natural gas industries — Drilling and production equipment — Part 1: Design and operation of marine drilling riser equipment
	API Spec 16R	Marine Drilling Riser Couplings	ISO 13625	Petroleum and natural gas industries -- Drilling and production equipment -- Marine drilling riser couplings
Expansion joints[1)]	EJMA	Standards of the expansion joint	EN 14917	Metal bellows expansion joints for pressure applications
Heat exchangers[1)]	TEMA	Tubular Exchangers Manufacturers Association standards	API Std 530 / ISO 13704	Calculation of Heater Tube Thickness in Petroleum Refineries
Lifting appliances	DNVGL-ST-0378	Standard for offshore and platform lifting appliances	FEM	Rules for the Design of Hoisting Appliances
	EN 280	Mobile elevating platforms		
Miscellaneous	ANSI/AISC 360-05	Specification for Structural Steel Buildings		
	API RP 17B	Recommended Practice for Flexible Pipe	ISO 13628-11	Petroleum and natural gas industries - Design and operation of subsea production systems - Part 11: Flexible pipe systems for subsea and marine applications
	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		

System/ equipment	*Reference no.*	*Title*	*Alternative reference no.*	*Title*
	API Spec 6DSS	Specification for Subsea Pipeline Valves		
	API Spec 16RCD	Specification for drill through equipment - Rotating control devices		
	API Spec 17J	Specification for Unbonded Flexible Pipe	ISO 13628-2	Petroleum and natural gas industries — Design and operation of subsea production systems — Part 2: Unbonded flexible pipe systems for subsea and marine applications
	API Spec 17K	Specification for Bonded Flexible Pipe	ISO 13628-10	Petroleum and natural gas industries — Design and operation of subsea production systems — Part 10: Specification for bonded flexible pipe
	ASTM D1418	Standard Practice for Rubber and Rubber-latices		
	ASTM D471	Immersion testing		
	DNVGL-CG-0051	Non-destructive testing		
	DNVGL-CG-0194	Hydraulic cylinders		
	DNVGL-OS-C501	Composite components		
	EN 1993-1	Eurocode 3: Design of steel structures		
	ISO 9712	Non-destructive testing - Qualification and certification of NDT personnel		
	ISO 10474	Steel and steel products - Inspection documents	EN 10204	Metallic Products - Type of Inspection Documents
	ISO 10675-1	Non-destructive testing of welds -- Acceptance levels for radiographic testing -- Part 1: Steel, nickel, titanium and their alloys	ISO 5817	Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections
	ISO 23277	Non-destructive testing of welds -- Penetrant testing -- Acceptance levels		
	ISO 23278	Non-destructive testing of welds -- Magnetic particle testing -- Acceptance levels		

System/ equipment	*Reference no.*	*Title*	*Alternative reference no.*	*Title*
	ISO 27509	Petroleum and natural gas industries - Compact flanged connections with IX seal ring		
Piping	API 526	Flanged Steel Pressure-relief Valves		
	ASME B1.20.1	Pipe Threads, General Purpose (Inch)		
	ASME B16.5	Pipe Flanges and Flanged Fittings		
	ASME B16.36	Orifice flanges		
	ASME B31.3	Process Piping		
	EN 1092	Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 1: Steel flanges		
	ISO 6162	Hydraulic fluid power - Flange connections with split or one-piece flange clamps and metric or inch screws		
	ISO 6164	Hydraulic fluid power - Four-screw, one-piece square-flange connections for use at pressures of 25 MPa and 40 MPa (250 bar and 400 bar)		
	ISO 14692	Glass-reinforced plastics (GRP) piping		
Pressure vessels	ASME Boiler and Pressure Vessel Code	Section VIII, Rules for Construction of Pressure Vessels	PD 5500	Specification for Unfired Fusion Welded Pressure Vessels
			EN 13445	Unfired pressure vessels
Well testing	API RP 14C	Analysis, Design, Installation and Testing of Basic Surface Safety Systems on Offshore Production Platforms	ISO 10418	Petroleum and natural gas industries - Offshore production platforms - Analysis, design, installation and testing of basic surface safety systems
	DNVGL-OS-E201	Oil and gas processing systems		

1) Normative references provided under pressure vessels are also acceptable.

4 Informative references

Informative references are not considered mandatory in the application of this offshore standard, but may be used for guidance and information.

Informative references are provided in Table 6.

Table 6 Informative references

Document code	*Title*
API Bul 6J	Bulletin on testing of oilfield elastomers
API Bul 16J	Comparison of Marine Drilling Riser Analyses
API RP 4G	Maintenance and Use of Drilling and Well Servicing Structures
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
API RP 14E	Design and Installation of Offshore Production Platform Piping Systems
API RP 14F	Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations
API RP 14J	Design and Hazards Analysis for Offshore Production Facilities
API RP 16Q	Design, Selection, Operation and Maintenance of Marine Drilling Riser Systems
API RP 17H	Remotely Operated Tools and Interfaces on Subsea Production Systems
API RP 520	Sizing, Selection and Installation of Pressure-relieving devices
API RP 92M	Managed Pressure Drilling Operations with Surface Back-pressure
API Standard 16AR	Standard for repair and remanufacture of drill-through equipment
API 17TR8	High-pressure High-temperature Design Guidelines
DNV-CN-30.1	Buckling strength analysis of bars and frames and spherical shells
DNV-OS-F201	Dynamic Risers
DNV-OTG-05	Temporary Equipment on Offshore Installations
DNV-OTG-07	Guidance on DNV GL's **DRILL** notation
DNV-RP-C201	Buckling Strength of Plated Structures
DNV-RP-D102	Failure Mode and Effect Analysis (FMEA) of Redundant Systems
DNV GL rules for lifts	DNV GL rules for classification: Ships and DNV GL rules for classification: Offshore units
DNVGL-CG-0339	Environmental test specification for electrical, electronic and programmable equipment and systems
DNVGL-CP-0183	Flexible hoses - Non-metallic materials
DNVGL-CP-0338	DNV GL type approval scheme
DNVGL-OS-A201	Winterization for cold climate operations

Document code	*Title*
DNVGL-OTG-11	Well test equipment survey
DNVGL-RP-0497	Data quality assessment framework
DNVGL-RP-A201	Winterization for cold climate operations
DNVGL-RP-A203	Technology qualification
DNVGL-RP-B301	Inspection and evaluation of non-metallic seals
DNVGL-RP-C203	Fatigue design of offshore steel structures
DNVGL-RP-C205	Environmental conditions and environmental loads
DNVGL-RP-C208	Determination of structural capacity by non-linear FE analysis methods
DNVGL-RP-D101	Structural analysis of piping systems
DNVGL-RP-O501	Managing sand production and erosion
DNVGL-ST-E273	2.7-3 Portable Offshore Units
ISO 13850	Safety of machinery - Emergency stop function - Principles for design
YA-711	Principles for alarm system design

CHAPTER 2 TECHNICAL PROVISIONS

SECTION 1 DESIGN PRINCIPLES

1 General

1.1 Introduction

This section provides the basic principles to be considered for design and layout of drilling facilities.

1.2 Objective

An overall of [1.2]objective for design of drilling facilities is that no single failure or unintentional operation shall result in life-threatening situations for personnel, or significant damage to environment or property.

1.3 Scope and application

1.3.1 Requirements apply to all drilling systems and equipment that have the potential to adversely affect safety of personnel or integrity of the environment or MODU/OI.

Guidance note:

To facilitate understanding and implementation of the design principles, functional and prescriptive requirements are provided.

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1.3.2 If a system or equipment not mentioned specifically in this standard is used to provide a specific function addressed in the standard, then that system or equipment shall comply with the principles and the applicable requirements for such functions.

Guidance note:

See also Ch.1 Sec.1 [1.3.3].

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2 Barrier management

2.1 General principles

2.1.1 The overall objective may be achieved through barrier management. The purpose of barrier management is to establish and maintain barriers so that the risk faced at any given time can be handled, by preventing an undesirable event from occurring, or by limiting the consequences should such an event occur.

Barrier management is the coordinated activities to establish and maintain barriers at all times, and includes the processes, systems, solutions and measures which must be in place to ensure the necessary risk reduction.

2.1.2 Barriers are technical, operational and organizational elements which are intended, individually or collectively, to:

— identify conditions that might lead to, or
— reduce the possibility for, or
— limit consequences of,

an error, hazard or incident.

Guidance note:

Hazards considered in this standard are provided in Sec.5, Sec.6 and Sec.7.

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2.1.3 A barrier function is the task or role of a barrier, e.g. preventing unintentional well influx, mitigating the consequence of dropped load, etc.

2.1.4 A barrier strategy is the result of a process that, based on the risk picture, describes and clarifies the barrier functions and elements that need to be implemented in order to establish adequate barriers to reduce the risk to an acceptable level.

2.1.5 This standard provides requirements to technical barriers and technical barrier elements.

Guidance note:

E.g. by requirements to barrier functions based on the categories provided in [3.3.2] and [3.3.3].

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3 Drilling systems

3.1 General

3.1.1 In this standard, drilling systems are divided into operative systems and safety systems.

Guidance note:

Drilling systems include systems and equipment required for drilling operations and well testing.

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3.1.2 Operative systems are systems required in order to perform the drilling operations as intended.

Guidance note:

Operative systems for drilling are described in [3.3].

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3.1.3 Safety systems are systems provided to prevent, detect and/or warn of an accidental event or abnormal condition in operative systems and/or to mitigate its effects.

Guidance note:

Safety systems for drilling are described in [3.4].

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

3.2 Performance requirements

3.2.1 General

3.2.1.1 Drilling systems, including all components and utilities, shall be designed to minimise risk of hazards to personnel, environment and property, by application of the technical requirements provided by this standard.

Guidance note:

Components and utilities include e.g. dedicated equipment, control and monitoring systems, hydraulic/pneumatic or electrical supply, etc.

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3.2.1.2 Drilling system design life shall be 20 years, unless otherwise specified.

For components with a service life less than the drilling system design life, replacement intervals shall be specified in the maintenance requirements and user manual.

3.2.1.3 Drilling systems shall be protected against excessive loads, pressure, temperature, speed and corrosive environment.

3.2.1.4 Performance requirements to functions and systems/equipment are dependent on their role as barrier elements. Performance parameters necessary to comply with relevant performance requirements shall be specified for operative systems and safety systems.

Typical performance parameters are provided in Table 1 (as applicable):

Table 1 Performance parameters

Parameter	*Value*	*Description*
System/equipment design limitations	SWL, pressure range, temperature range, RPM, fluid service, speed, etc.	Various performance parameters, typically used for operative systems/equipment.
Response to failures/safe state	Shutdown/maintain operation	Specification of the response to a failure/the assumed safe state. Equal or different than operational state. See [3.2.2].
Type	On demand/continuous	On demand means that the function shall be activated when a given demand or state occurs. Continuous means that the function is available during normal operation.
Restoration time	[sec/min/hours]	The time needed to bring a function/system back in operation after a failure condition. See [3.2.3].
Response time	[sec/min/hours]	Maximum time from function initiation to function is completed.
Energy principle	NE/NDE	Normally energised (NE) is a circuit where energy is present when the circuit is not activated by activating function. Normally de-energised (NDE) is a circuit where energy is present when the circuit is activated by activating function.
Activation	Automatic/manual	Automatic activation means that the function shall be triggered by the system without manual operator intervention. Manual activation means that operator shall trigger the activation (e.g. by means of button or joystick).

3.2.1.5 System/equipment specific performance requirements are provided in Sec.5, Sec.6 and Sec.7.

3.2.2 Response to failures/safe state

3.2.2.1 The most probable failures, e.g. loss of power, utilities, component, wire failures, etc., shall result in the least critical of any possible condition, for all relevant operational modes. This shall include consideration of the safety of the systems themselves, as well as the safety of the MODU/OI.

3.2.2.2 Safety systems and systems providing essential or important functions, (see [3.3] and [3.4]) shall have facilities to detect the most probable failures (i.e. self-check facilities) that can cause erroneous or reduced system performance or which could affect the integrity or safety of the equipment or the MODU/OI.

3.2.2.3 Self-check facilities shall as a minimum cover the failure types in DNVGL-OS-D202 Ch.2 Sec.1 [3.1.2].

Detection of failures shall initiate an alarm.

Guidance note:

Adequate failure detection may be obtained by combining two independent systems, which together provide the required failure detection functionality.

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3.2.3 Restoration time

3.2.3.1 Required restoration time for a function is dependent on the risk related to that function being unavailable.

3.2.3.2 Redundant systems/components shall be installed to the extent necessary to maintain required functionality and performance.

Changeover between redundant systems/components shall be simple, easily initiated and shall be available in the event of failure.

Guidance note:

Some degree of redundancy is normally necessary in order to meet required functionality and restoration time (e.g. for control and monitoring systems), or where quick repair/replacement is difficult (e.g. located subsea/submerged). For equipment (structural/mechanical or pressure-containing/-retaining), redundancy is normally not necessary, as use of appropriate design codes, safety factors and production methods, as stipulated in this standard, ensure required functionality.

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3.2.3.3 For control and monitoring systems, maximum restoration time is provided for the different categories:

Table 2 Categories and maximum restoration time

Category	*Description*	*Restoration time*	*Changeover*	*User interface*
R0	Designed such that there is no interruption of the functionality during normal operation modes or in case of a single failure	None	Changeover between redundant systems shall take place automatically and with no disturbance to the continuous operation of the function in case of a single failure	User interfaces of redundant systems shall allow supervision of both systems from the same position

Category	*Description*	*Restoration time*	*Changeover*	*User interface*
R1	Designed to provide restoration of the function within the maximum time specified in case of a failure	30 seconds	Changeover between redundant systems shall take place automatically. User requested changeovers shall be simple, easily initiated, and shall take place within the maximum restoration time	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
R2	Designed to provide restoration of the function within the maximum time specified in case of a failure	10 minutes	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 control stations when required, provided such manning is immediately available
R3	Designed to provide restoration of the function within the maximum time specified in case of a failure	3 hours	Restoring a function may involve a number of manual operations, including minor replacements or repair of equipment	

3.3 Operative systems

3.3.1 General

3.3.1.1 Operative systems (including control/monitoring and utilities) shall be designed to minimise risk of hazards to personnel, environment and property.

Guidance note:

Where practicable, hazards should be avoided or prevented through safe design such that further protection is not required.

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3.3.1.2 Operative systems and equipment shall be provided with indicating instruments which will provide the necessary information for safe operation and control.

3.3.1.3 Operative systems provide functions which can be categorized as essential, important or less-important, based on potential consequence of failure.

3.3.2 Essential functions

3.3.2.1 An essential function is a function, failure of which could create an immediate danger to personnel, environment, or the MODU/OI.

3.3.2.2 Essential functions shall have safe state maintain operation, (see Table 1) and comply with performance requirements provided in Sec.5, Sec.6 and Sec.7.

3.3.2.3 Essential functions shall have two barriers in place; an operative barrier provided by the operative system and a safety barrier provided by a safety system.

3.3.2.4 The operative barrier and barrier elements shall be independent of the safety barrier and safety barrier elements.

Guidance note:

For alternative solutions, see Ch.1 Sec.1 [1.3.4].

In order to reduce the probability for common cause failures, the two barriers should be provided by functionally different types of devices.

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3.3.2.5 Necessary redundancy shall be built into the operative system to ensure maintained operation after any single failure in the operative system, its control or utilities.

3.3.2.6 Control and monitoring systems for essential functions shall comply with requirements for category R0 in Table 2.

3.3.2.7 If failure occurs in the operative system, the corresponding safety system shall bring the operative system/processes into a predefined *safe state* and alarm shall be initiated. Safe state shall be defined for all relevant operational modes and failures.

As essential functions are functions which shall be continuously available, the safe state response will normally be to maintain operation. Necessary redundancy shall therefore be implemented in the operative barrier, ensuring required functionality for all single-failure scenarios.

Guidance note:

The safe state is the system/equipment state which is defined as the safest for each relevant operation if failure should occur, see [3.2.2].

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3.3.2.8 For systems providing essential functions, an FMEA or equivalent shall be performed.

Guidance note:

FMEA is a detailed technical assessment of the system and components. To identify the required extent and focus area of the FMEA assessments, hazard identification and/or operability studies may be performed.

FMEA is required for e.g. heave compensation systems (for floating MODUs). See Sec.5, Sec.6 and Sec.7 for essential functions.

FMEA assessment is related to a specific design, and not to the manufactured product(s). An already evaluated design does not need repeated assessments.

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3.3.2.9 Requirements to an essential function are applicable to all resources required to execute that function.

Guidance note:

Such resources include all systems/equipment necessary to ensure that the function is available. This will normally include equipment, utilities (e.g. hydraulic/pneumatic or electrical supply) and control/monitoring systems.

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3.3.3 Important functions

3.3.3.1 An important function is a function, failure of which could impair the safety of personnel, environment or the MODU/OI, but it would not create an immediate danger.

3.3.3.2 Important functions shall comply with performance requirements provided in Sec.5, Sec.6 and Sec.7.

3.3.3.3 Important functions shall have two barriers in place, an operative barrier provided by the operative system and a safety barrier provided by a safety system.

3.3.3.4 The operative barrier and barrier elements shall be independent of the safety barrier and safety barrier elements.

Guidance note:

For alternative solutions, see Ch.1 Sec.1 [1.3.4].

In order to reduce the probability for common cause failures, the two barriers should be provided by functionally different types of devices.

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3.3.3.5 If a failure occurs in the operative system, the corresponding safety system shall bring the operative system/processes into a predefined *safe state* and alarm shall be initiated. Safe state shall be defined for all relevant operational modes and failures.

Guidance note:

The safe state is the system/equipment state which is defined as the safest for each relevant operation if failure should occur. See [3.2.2].

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3.3.3.6 For systems providing important functions, an FMEA or equivalent shall be performed.

Guidance note:

FMEA is a detailed technical assessment of the system and components. To identify the required extent and focus area of the FMEA assessments, hazard identification and/or operability studies may be performed.

FMEA is consequently required for e.g. MPD systems. See Sec.5, Sec.6 and Sec.7 for important functions.

FMEA assessment is related to a specific design, and not to the manufactured product(s). Manufacturing of an already evaluated design, does not need repeated assessments.

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3.3.3.7 Requirements to an important function are applicable to all resources required to execute that function.

Guidance note:

Such resources include all systems/equipment necessary to ensure that the function is available. This will normally include equipment, utilities (e.g. hydraulic/pneumatic or electrical supply) and control/monitoring systems.

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3.3.4 Less-important functions

3.3.4.1 A less-important function is a function, failure of which would not create a danger to personnel, environment or the MODU/OI.

3.3.4.2 Systems and equipment only providing less-important functions shall comply with applicable and recognised codes and standards.

3.4 Safety systems

3.4.1 General

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

3.4.1.2 A safety system is defined as a system that is provided to prevent, detect/warn of an accidental event/abnormal conditions and/or mitigate its effects.

Safety systems are provided in order to perform safety functions for operative systems, and shall include all resources required to execute the safety functions.

Guidance note:

Such resources include all systems/equipment necessary to ensure that the safety function is available. This will normally include equipment, utilities (e.g. hydraulic/pneumatic or electrical supply) and control/monitoring systems.

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3.4.1.3 General requirements to safety systems are provided in respective DNV GL standards, e.g. DNVGL-OS-A101, DNVGL-OS-D202 and DNVGL-OS-D301. For well testing plant, shutdown, and blowdown systems, see also DNVGL-OS-E201.

Guidance note:

See also applicable requirements for drilling safety systems in the normative standards provided in Ch.1 Sec.1 [3].

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3.4.1.4 Safety systems, including their resources, shall be independent of operative systems, making safety functions independent of drilling operative functions. Effectively, a failure in an operative function shall not have any impact on a safety function.

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 functions as a principle are independent of operative functions, it might be accepted that some safety functions are performed or supported by a drilling operative system (e.g. overload protection, monitoring of safety functions). In this scenario, the overall safety level must be ensured, and it is of essence to avoid common cause failures.

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3.4.1.5 Data may be transferred from a safety system to an operative system for monitoring purposes, provided data is in “read only” format. No data or commands shall be transferred from the operative system to the safety system.

3.4.1.6 Safety systems (two or more) which might be required to operate simultaneously during a hazardous event shall be controlled from the same physical location. Alternatively, efficient visual and/or audible communication facilities shall be available, also after emergency shutdown.

3.4.1.7 If failure occurs in the operative system, the corresponding safety system shall bring the operative system/processes into a predefined *safe state*.

Safe state shall be defined for all relevant operational modes and failures.

Guidance note:

The safe state is the system/equipment state which is defined as the safest for each relevant operation if failure should occur. See [3.2.2].

Activation of the safety system may be manual or automatic.

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3.4.1.8 If failure occurs in the safety system, the safety system shall bring the operative system/processes into a predefined *safe state*. Alternatively, if a failure occurs in the safety system, alarm shall be given at a manned control station and the operative system/processes shall be brought to a controlled stop until the safety system has been restored.

3.4.1.9 Following activation of a safety function/system, it shall not be possible to restart the operative system before it has been reset manually, individually and intentionally.

Guidance note:

For machines without self-check possibilities, reset of the operative system should include more than one operator action. This may be obtained with an allow-reset function prior to the actual resetting.

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3.4.1.10 Control and monitoring systems for safety functions shall comply with requirements for category R0 in Table 2.

3.4.1.11 Safety systems and relevant controls shall be located, or otherwise protected, so as to remain operational and safely accessible for the time required, during and following an uncontrolled situation or defined hazardous event.

Guidance note:

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

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3.4.1.12 Control stations for drilling safety systems shall not be located in exposed areas of the drill floor/ moon pool.

3.4.1.13 Control hoses, cables, and other equipment 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 and following a defined hazardous events.

3.4.1.14 Back-up supplies shall be provided to enable safety systems to remain available for the time required, during and following a defined hazardous event.

Guidance note:

See applicable normative references in Ch.1 Sec.1 [3].

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3.4.1.15 Electrical equipment required to remain operative in areas potentially affected by a gas release shall as a minimum be certified for hazardous area zone 2.

Guidance note:

See also DNVGL-OS-A101 Ch.2.

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3.4.1.16 If overriding a safety function is possible, the override shall be arranged such that unintentional activation is prevented. The operator shall have clear indication whenever an override is active.

3.4.1.17 Special considerations shall be made where hazardous events may develop too quickly to be counteracted by local manual intervention.

3.4.1.18 For systems providing safety functions, an FMEA or equivalent shall be performed.

Guidance note:

FMEA is a detailed technical assessment of the system and components. To identify the required extent and focus area of the FMEA assessments, hazard identification and/or operability studies may be performed.

An FMEA is consequently required for e.g. BOP systems (WSD), diverter systems, etc. See Sec.5, Sec.6 and Sec.7 for safety functions.

FMEA assessment is related to a specific design, and not to the manufactured product(s). Manufacturing of an already evaluated design, does not need repeated assessments.

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SECTION 2 MATERIALS

1 Introduction

1.1 Scope

This section describes requirements for the following:

— materials
— welding
— corrosion.

1.2 General

1.2.1 Manufacturer shall utilise necessary production facilities, qualifications, procedures, and personnel to ensure that products are manufactured to specified requirements.

1.2.2 Materials shall be suitable for the purpose and have adequate properties of strength, notch toughness, ductility and corrosion resistance (as applicable).

Materials to be welded shall also have acceptable weldability properties.

Guidance note:

Adequate corrosion resistance may be based on material selection and/or other protective systems.

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1.2.3 Materials shall, unless otherwise agreed, be specified in accordance with recognised standards.

Material specifications shall specify material properties and testing procedures, including NDT (as applicable).

Guidance note:

A recognised standard will typically provide the following:

— manufacturing process
— chemical composition
— heat treatment/delivery condition
— sampling for mechanical properties testing, e.g. sampling process, sampling frequency, at what stage of manufacturing process, location of sample within product, sizes, etc.
— mechanical properties (including thickness dependency)
— dimensional tolerances
— NDT, where relevant.

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

The specification for materials not in accordance with a recognised standard shall also include information regarding the steel making process.

1.2.4 Mechanical properties for the final component shall be documented by testing, after final heat treatment cycle.

1.2.5 The material application for a part or component shall be designated as one, or a combination of, the following:

— structural (special area, primary, secondary)
— mechanical (special area, primary, secondary)
— pressure-containing

— pressure-retaining
— pressure-controlling.

1.2.6 Bolting material shall be consistent with the systems where the bolted connections are applied.

Consideration shall be given to:

— nature of external loading
— load in bolt(s)
— design/capacity of bolted connection
— impact properties at system MDT or lower
— environmental conditions (e.g. min/max temperature, corrosive environment, etc.)
— consequence of failure
— fit-up tolerance.

2 Materials and welding

2.1 Rolled steel

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

2.1.2 Location of Charpy V-notch impact test specimens relative to final product shall be:

— 2 mm below the surface representing the final machined component for thickness (t) ≤ 40 mm, or
— t/4 below the surface representing the final machined component for thickness (t) > 40 mm.

2.1.3 Plates that transfer significant loads in the thickness direction (Z-direction) shall have through thickness ductility in order to reduce the probability of lamellar tearing. The minimum reduction of area, Zz, shall not be less than 25% (quality class Z25).

Guidance note:

Significant 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.

With particular attention to connections where full penetration welds are used.

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

2.2 Steel forgings and castings

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

2.2.2 Mechanical test specimens shall be taken from a location representing t/4 below surface of final machined component, where t is the thickness.

Where applicable, the specimens shall be taken at a depth of t/4 from the inner surface.

Guidance note:

E.g. for BOP bodies, valve bodies, etc.

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

2.3 Cast iron

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

2.3.2 Cast iron shall not be used for components providing essential, important or safety functions, if MDT is below 0°C.

Guidance note:

Nodular cast iron might be accepted on a case-by-case basis for specific applications (e.g. sheaves, valve bodies).

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

2.3.3 Mechanical test specimens shall be in accordance with the requirements provided in [2.2.2].

2.4 Steel piping

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

2.4.2 Welded carbon and carbon-manganese steel shall, unless otherwise agreed, conform to a carbon equivalent C_{eq} of maximum 0.50% as determined by the following formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

Guidance note:

Welding of such materials normally requires more stringent manufacturing procedures regarding selection of consumables, preheating, post weld heat treatment and NDT, (see Sec.8 [3.1.1.6]).

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

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

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

2.5 Other metallic materials

Aluminium, copper, and other non-ferrous alloys shall be in compliance with DNVGL-OS-B101.

2.6 Materials for specific applications

2.6.1 Mechanical and structural

2.6.1.1 This subsection applies to materials used for special area and primary structural members/ mechanical components.

2.6.1.2 Welded carbon, carbon-manganese and low alloy steels shall, unless otherwise agreed, conform to the following carbon (C)- and carbon equivalent (C_{eq})-values:

$$C \leq 0.22 \ \%$$

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad \leq 0.45\ \%$$

Guidance note:

For drilling risers, (see Sec.7 [7]), this may be exempted provided compliance with normative reference.

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

2.6.1.3 Impact testing is required, unless otherwise agreed, 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.

2.6.1.4 Materials for mechanical and structural components shall be manufactured from materials having minimum Charpy-V impact toughness, for longitudinal specimens, according to Table 1:

Table 1 Average minimum Charpy V-notch energy absorption

Specified minimum yield strength (MPa)	*Charpy V-notch energy (J)*
Yield strength ≤ 270	27
270 < Yield strength < 420	10% of yield strength
Yield strength ≥ 420	42

The requirement shall be met as an average of 3 specimens, with no individual value less than 2/3 of the specified minimum average.

If only values for transverse specimens are available, 2/3 of the values in Table 1 shall be met.

Guidance note:

Rolled structural steel with a minimum yield strength between 270 MPa and 420 MPa, and delivered in normalised condition, may be accepted with minimum longitudinal Charpy V-notch value of 27J at MDT, provided that the materials are delivered in accordance with internationally recognised standards such as ISO, EN or ASTM, and are suitable for their intended application.

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

2.6.1.5 Where standard test specimens for Charpy V-notch impact test cannot be made, sub-size specimens may be used. Energy conversion factors shall be according to Table 2:

Table 2 Average Charpy V-notch energy absorption

Specimen section (mm^2)	*Energy factor*
10 × 10	1
10 × 7.5	5/6
10 × 5	2/3

2.6.1.6 Impact property requirements for bolts, and for custom designed nuts and washers, when applied in special area or primary structural members/mechanical components, with MDT below 0°C, shall conform to [2.6.1.4].

Guidance note:

Bolts fully compliant with ISO 898-1 may be accepted with minimum longitudinal Charpy V-notch value of 27J at MDT (not applicable for BOP main body, see [2.6.2.1]).

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

The requirement shall be met as an average of 3 specimens, with no individual value less than 2/3 of the specified minimum average.

If only values for transverse specimens are available, 2/3 of the required values shall be met.

2.6.1.7 Bolts in an atmospheric environment shall have specified properties which, unless otherwise agreed, do not exceed ISO 898-1 property class 10.9, ASTM A540 B22/B23, or equivalent.

Vickers hardness number (HV10) shall not exceed 385, unless otherwise agreed.

2.6.2 Pressure-containing and pressure-retaining

2.6.2.1 BOP main body (including connectors, preventers, flanges, bolts and C&K outlet connections) shall be manufactured from materials having minimum impact toughness in accordance with [2.6.1.4].

2.6.2.2 Components (including piping, bolts, etc.) shall be manufactured from materials having minimum longitudinal Charpy V-notch impact toughness of 27 J, if the Minimum Design Temperature (MDT) is below 0°C, for the following systems:

— High pressure systems providing safety or essential/important functions (e.g. BOP riser conduit line)

and for components exposed to wellbore fluids in the following systems:

— choke and kill system (including BOP stack mounted piping)
— diverter system
— surface drilling riser above BOP
— well test system.

Guidance note 1:

For systems not covered, and in general, see applicable design code requirements (e.g. ASME B31.3 Chapter III 323.3 or Chapter IX Part 7 K323.3). Note that Charpy impact test requirements might apply to material ASTM A106 Gr.B (dependent on MDT and nominal wall thickness).

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

The requirement shall be met as an average of 3 specimens, with no individual value less than 2/3 of the specified minimum average.

If only transverse values are available, 2/3 of the required values shall be met.

Where standard test specimens for Charpy V-notch impact test cannot be made, [2.6.1.5] shall apply.

Guidance note 2:

This requirement may be exempted for bolts if the following three conditions are fulfilled:

— diameter at or below 16 mm
— supporting a less-important function
— in accordance with a normative standard, (see Ch.1 Sec.1 [3]).

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

Impact testing is required for custom designed nuts and washers.

2.6.2.3 Pressure containing components shall, unless otherwise agreed, be forged to shape, or cast to shape.

If such components are allowed by normative reference code to be machined from bar stock or plate (forged or rolled), the material shall be tested in the transverse direction and shall meet the acceptance criteria for longitudinal specimens. If machined from plate, testing shall also be performed in the short-transverse (through thickness) direction and shall meet the acceptance criteria for transverse specimens.

2.6.2.4 Bolts in submerged environment shall have specified properties which, unless otherwise agreed, do not exceed ISO 898-1 property class 8.8, ASTM A193 B7, ASTM A320 L7/L43, or equivalent.

Vickers hardness number (HV10) shall not exceed 350.

2.6.3 Pressure-controlling

2.6.3.1 Materials for pressure-controlling components shall be manufactured from materials having minimum Charpy V-notch impact toughness of 27 J for longitudinal specimens (regardless of material thickness), if the minimum design temperature (MDT) is below 0°C and if part of one of the following:

— BOP stack pressure-controlling components in contact with wellbore fluids (including ram blocks, choke/kill line valves part of the BOP, etc.).
— Diverter valves (including relief valves in riser gas handling systems, relief valves in MPD back-pressure systems, etc.).

The requirement shall be met as an average of 3 specimens, with no individual value less than 2/3 of the specified minimum average.

If only transverse values are available, 2/3 of the required values shall be met.

Where standard test specimens for Charpy V-notch impact test cannot be made, [2.6.1.5] shall apply.

2.6.3.2 For bolts in submerged environment, see [2.6.2.4].

2.7 Non-metallic materials

2.7.1 Non-metallic materials shall be suitable for the intended service and shall be capable of sustaining the design pressures and temperatures.

2.7.2 Non-metallic materials in wetted components shall be tested in order to ensure compatibility with all fluids that they will be exposed to during service, as specified.

Test scope shall be according to the applicable normative reference.

Guidance note:

E.g. API Spec 6A - Annex F.

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

Where normative reference does not specify a test scope, testing shall be planned for and described in a test plan.

3 Corrosion

3.1 General

3.1.1 Materials shall have adequate corrosion resistance.

3.1.2 Corrosion allowance (i.e. extra wall thickness to compensate for metal loss by corrosion), as specified in Sec.3 Table 1, shall be applied for wetted components (including piping).

Guidance note:

The allowance may be applied either alone, or in combination with a corrosion protective system.

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

3.1.3 Selection of materials and corrosion protective systems, where such systems are installed, shall ensure mutual compatibility, taking into account the effect of relevant operational parameters, techniques for inspection, monitoring and maintenance, and the required design life.

Guidance note:

Corrosion protection systems are e.g. coatings, cathodic protection, chemical treatment, etc.

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

3.1.4 Metallic materials (including bolts) potentially exposed to H_2S shall be selected according to NACE MR0175/ISO 15156.

Any welding or other manufacturing process affecting mechanical properties shall be carried out according to a qualified procedure.

4 High-pressure high-temperature applications

4.1 General

4.1.1 Systems and equipment which will be exposed to an high-pressure high-temperature (HPHT) environment shall be designed to withstand all relevant design loads.

Guidance note:

See Sec.3 [1.2] for piping systems.

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

4.1.2 For metallic materials and components, the potential effect of the following shall be considered, as a minimum:

— increase in partial pressure of H_2S (and CO_2, where relevant)
— accelerated corrosion
— dissimilar expansion.

Guidance note:

Consequences might be to chose materials with enhanced corrosion resistance, add corrosion allowance, de-rating of material properties (based on factors recommended by recognised standards), additional testing, etc.

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

4.1.3 For non-metallic materials and components, the potential effect of the following shall be considered, as a minimum:

— sealing performance
— accelerated aging
— thermal properties.

Guidance note:

Consequences might be additional design validation/verification testing, due to limited experience with extreme pressures/ temperatures on materials and/or geometries.

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

4.1.4 Systems and equipment shall be design validation/verification tested.

Tests shall cover all relevant loads and effects, (see [4.1.1], [4.1.2] and [4.1.3]).

SECTION 3 PIPING

1 Introduction

1.1 Scope

This section describes requirements for the following:

— piping systems
— piping components
  — pipes
  — flexible hoses
  — valves
  — pipe fittings
— piping supports
  — support elements and penetrations.

Guidance note:

See Ch.1 Sec.1 Table 2 for definitions.

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

1.2 General

The following shall be considered (as a minimum) for design evaluation and possible piping failure modes (as applicable):

— corrosion, erosion and fabrication tolerances
— material properties (at minimum and maximum design temperatures)
— fatigue (including stress amplitudes due to temperature variations)
— internal and external pressure
— weight (component, content and external)
— accelerations (motion loads, earthquake, etc., see Sec.5 [5])
— wind loads
— wave drag loads
— loads caused by temperature changes
— vibration (from vortex shedding, pressure pulsations, slugs, etc.)
— loads from hydraulic hammer effects, surge
— PSV reaction forces
— friction forces (for support clamps)
— interface loads from connected piping and hoses
— forced movements from connected equipment, hull, structure and pipe supports
— accidental loads.

Guidance note:

See Sec.5 [5], ASME B31.3 and DNVGL-RP-D101.

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

2 Piping systems

2.1 General

2.1.1 Piping systems used to provide safety functions shall, unless otherwise agreed, be separated from piping systems used for operating functions. If cross connections cannot be avoided, a risk assessment shall be performed and necessary measures shall be implemented.

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

Guidance note:

E.g. one diameter nominal size larger for the downstream piping relative to the upstream piping is recommended.

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

2.2 Pipe stress and flexibility analysis

2.2.1 Pipe stress and flexibility analysis shall be performed for piping in the following systems:

— choke and kill system
— hydraulic drilling hoisting system
— permanent well test piping
— all high pressure systems.

Guidance note:

This includes manifold piping.

Analysis for hydraulic distribution lines below 3" (OD) may be exempted. Above 3" (OD) might be accepted on a case-by-case basis.

See Ch.1 Sec.1 Table 2 for definition of high pressure.

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

2.2.2 The analysis shall be performed in accordance with ASME B31.3.

Guidance note:

See DNVGL-RP-D101 for guidance. For analysis tools, see DNVGL-RP-D101 [2.3].

The fatigue analysis specified in ASME B31.3 may be carried out according to the methodology provided in PD5500 or ASME VIII.

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

2.2.3 All design loads and load combinations listed in [1.2] shall be evaluated (as applicable).

Guidance note:

See DNVGL-RP-D101 [3.4].

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

2.2.4 Flange utilization or leakage calculations shall as a minimum be performed and documented for the highest loaded flange pair for each pipe size and pressure class.

Guidance note:

Additional information is provided in DNVGL-RP-D101 [3.8].

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

2.2.5 Nozzle loads obtained from the pipe stress and flexibility analysis shall be within the specified allowable nozzle loads. Allowable nozzle loads shall be stated on equipment general arrangement drawings.

Guidance note:

Unless explicitly specified otherwise, the following loads should be applied in order to establish allowable nozzle load capacities for skid/equipment in a piping system:

— Bending moment:

$$M = 4 \times (DN - 25)^{1.4} + 2 \times 10^{-5} \times PN \times DN^{2.7} \text{ [Nm]}$$

— Force:

$$F = 7.5 \times DN^{1.2} + 0.1 \times PN \times DN^{1.2} \text{ [N]}$$

Where

$PN =$ pressure rating in bars

$DN =$ nominal diameter in millimeters

Bending moments and forces shall be applied simultaneously in two perpendicular directions, causing bending and shear forces in the nozzle coupling in combination with axial force.

Alternatively, the resulting bending moment and resulting shear forces can be used instead of individual bending moments and individual shear forces.

The above equations are applicable for temperatures up to 177°C (350°F). Above these temperatures, special considerations to be made and evaluated on a case-by-case basis.

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

3 Piping components

3.1 General

3.1.1 Pipes and fittings that are not in compliance with requirements for dimensions and materials in ASME B31.3 and/or applicable API specifications, shall be designed according to the FEA methodology referred to in ASME B31.3.

Guidance note:

This refer to ASME VIII Division 2 and 3, which do not accept traditional elastic-stress analysis, but require either a methodology based on elastic-plastic analysis or based on stress-linearization. See ASME B31.3, 304.7.2 or K304.7.2 (as applicable).

Note that normative references might have specific FEA methodologies that apply.

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

3.1.2 Calculations of branch reinforcements for pipes and fittings shall be according to ASME B31.3.

3.2 Pipes

3.2.1 Design code for pipes shall be ASME B31.3 and/or applicable API specifications.

3.2.2 Wall thickness calculations shall ensure that pipes have the required strength throughout their operational life.

In addition to the stresses arising from the internal pressure, piping shall be designed with necessary flexibility and resistance to withstand the loads in [1.2].

3.2.3 Wall thickness calculations

3.2.3.1 Minimum pressure design wall thickness of pipes (t) shall be calculated according to ASME B31.3, Chapter II or Chapter IX (as applicable).

Guidance note:

Material properties at elevated design temperatures for unlisted materials per ASME B31.3 should be taken from normative references (e.g. for ASTM A519 Grade 4130, see API Spec 6A, Annex G, Table G-4).

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

3.2.3.2 Selected standard catalogue wall thickness (T) for an actual pipe size shall meet the following criteria:

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

Where

t_m	= t + allowances
t	= pressure design wall thickness, calculated according to ASME B31.3, Chapter II or Chapter IX (as applicable)
allowances	= corrosion + erosion+ thread depths
a	= wall thickness fabrication tolerance, given as a percentage [%] **Guidance note:** Typically 12.5% for ordinary piping. ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

If the wall thickness fabrication tolerance is given in millimeters in stead of percentage, the following apply:

$$T \geq t_m + MT$$

Where

MT	= wall thickness fabrication tolerance, given in millimeters [mm].

3.2.4 Allowances

3.2.4.1 Allowances for threads, corrosion and erosion shall be added to the minimum pressure design wall thickness (t):

— Allowance for threads, see [3.2.4.2].
— Corrosion allowance, see [3.2.4.3], [3.2.4.4] and [3.2.4.5].
— Erosion allowance, see [3.2.4.6].

3.2.4.2 Calculated minimum strength thickness of piping which shall be threaded, shall be increased by an allowance equal to thread depth, dimension *h* of ASME B1.20.1 or equivalent shall apply.

For machined surfaces or grooves where the tolerance is not specified, the tolerance shall be 0.5 mm (0.02 in) in addition to the specified depth of cut.

3.2.4.3 Corrosion allowance for steel pipes (c) shall be as specified in Table 1.

Guidance note:

Corrosion allowance may be reduced down to zero where the medium has negligible corrosive effect on the material employed.

A greater corrosion allowance should be considered for pipes where there is a risk of heavy corrosion and/or erosion.

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

Table 1 Minimum corrosion allowance for steel pipes

Application[1,2,3,4]	*c (mm)*
Well test/hydrocarbons	2
Mud (including MPD), cement, choke & kill and diverter lines	3

1) See DNVGL-OS-D101 Ch.2 Sec.2 for corrosion allowances for other systems.
2) For pipes passing through tanks, an additional allowance for external corrosion shall be considered according to the figures given depending on the external medium.
3) For pipes efficiently protected against corrosion, the corrosion allowance may upon approval be reduced (max. 50% reduction).
4) For stainless steels the corrosion allowance may be omitted.

3.2.4.4 Pipes of copper, brass, copper-tin alloys and Cu-Ni alloys with Ni-content < 10% shall have minimum corrosion allowance of 0.8 mm (0.03 in).

3.2.4.5 Pipes of Cu-Ni alloys with Ni-content ≥ 10% shall have minimum corrosion allowance of 0.5 mm (0.02 in).

3.2.4.6 Where piping is likely to be exposed to erosion, an erosion allowance shall be specified based on analysis or equivalent. The allowance shall be suitable for all specified service conditions.

Guidance note:

Erosion analysis for specific systems:

- MPD systems, see Sec.7 [3.2.7.4].
- BOP choke/kill line outlets, see Sec.7 [4.2.3].
- Diverter systems, see Sec.7 [5.2.5].
- Choke and kill systems, see Sec.7 [6.2.14].

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

3.3 Flexible hoses

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

Guidance note:

Flexible hoses which are suitable for the intended use may be installed in locations where pipes are unsuitable.

Documentation on fluid compatibility might be required.

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

3.3.2 Installed flexible hoses shall be accessible for inspection.

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

3.3.4 Submerged hoses shall be qualified for the external pressure they might be exposed to.

3.3.5 A fire test according to IMO Res. A.753(18), ISO 15540, ISO 15541, API 16C or equivalent shall be performed on hose assemblies for:

— flammable fluids systems.

Guidance note 1:

With flammable fluid it is meant any fluid capable of feeding a fire, regardless of its flash point. Examples are diesel fuel, hydraulic oil (oil-based), lubricating oil, crude oil, hydrocarbons or oil-based mud.

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

— systems where the fluid provides an essential or a safety function.

Guidance note 2:

Flexible control lines and supply hoses to a subsea BOP do not require fire test, see API Standard 53.

See Sec.5, Sec.6 and Sec.7 for functions categorized as essential or safety.

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

3.3.6 Design of flexible hoses shall be according to relevant normative references, (see Ch.1 Sec.1 [3]) and as provided in Table 2 for specific applications.

Guidance note:

Where more than one standard is provided for a specific hose application, these are to be considered alternatives. For each alternative, applicable requirements follow on same row.

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

Table 2 Requirements for specific applications

Application	*Design code*	*DNV GL additional fire test requirements[1)]*	*DNV GL other additional requirements*
Cement hose	API Spec 7K	None	None
Mud rotary hose	API Spec 7K	According to API Spec 16C or equivalent (5 minutes holding time is acceptable)	None
Mud booster hose (in moon pool)	API Spec 7K	According to API Spec 16C or equivalent (5 minutes holding time is acceptable)	3)
Choke & kill hose (topside)	API Spec 16C	According to API Spec 16C	None
LMRP choke & kill hose (subsea)	API Spec 16C	None	6)
LMRP booster and hydraulic conduit hose (subsea)	API Spec 7K	None	5) 6)
	API Spec 16C	None	6)
Control hoses for surface BOP stacks	Fit-for-purpose design according to suitable hydraulic hose standard (e.g. ordinary machinery hoses in DNVGL-CP-0183) and API Spec 16D	API Spec 16D (regardless of area classification)	None

Application	*Design code*	*DNV GL additional fire test requirements*[1)]	*DNV GL other additional requirements*
Control hoses for subsea BOP stacks (e.g. umbilicals/ bundles) and hotline hose	Fit-for-purpose design according to suitable hydraulic hose standard (e.g. ordinary machinery hoses in DNVGL-CP-0183) and API Spec 16D	None	6)
Hydraulic conduit hose for subsea BOP stacks (in moon pool)	API Spec 7K	None	3) 5)
	API Spec 16C	None	None
Riser tensioner and heave compensation hose (fluid- and gas side)	API Spec 17K	30 minutes according to API Spec 16C or equivalent	Relevant considerations to be made[2) 3)]
	API Spec 17J		
Well test hose	API Spec 17K	30 minutes according to API Spec 16C or equivalent	None
	API Spec 17J		
	API Spec 16C		5)
MPD mud return hose	API Spec 17K	According to API Spec 16C or equivalent (5 minutes holding time is acceptable)	Relevant considerations to be made[2) 3)]
	API Spec 17J		
	API Spec 16C		2) 4)
	API Spec 7K		2) 3) 4) 5)
Hose for safety or essential/ important functions	API Spec 17K	30 minutes according to API Spec 16C or equivalent	Relevant considerations to be made[2) 3)]
	API Spec 17J		

1) Flexible hose body with end termination (as a minimum) shall be subjected to the fire test. Applicable design code(s) might have specific requirements to fire tests.
2) Liner collapse and blistering due to rapid decompression shall be accounted for.
3) Environmental loads, e.g. slamming loads in moon pool shall be accounted for.
4) Erosion shall be accounted for.
5) Fluid compatibility test shall be performed.
6) Collapse loads (according to suitable standard) shall be accounted for.

3.3.7 If design validation/verification testing is intended to qualify a hose design family, all structural design parameters for the tested hose assembly shall also be relevant for the other members of the design family.

3.3.8 If fire testing of a hose assembly is intended to qualify a hose design family, the test shall be performed on the most critical design family member.

Guidance note:

For fire tests, the hose with the smallest outer diameter and the least amount of structural metal in the hose body is normally seen as the most critical.

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

3.4 Valves

3.4.1 Threaded valve bonnets shall not be used in equipment/systems part of a safety barrier.

For other equipment/systems, it may be used if nominal diameter is below 50 mm, or if the following conditions are met:

- the threaded connection is not part of the seal
- the threads are straight threads (e.g. ACME)
- the bonnet is secured against loosening.

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

3.4.3 Closing time of valves shall be such that it is suitable for timely execution of its function, while simultaneously not inducing detrimental stresses due to hydraulic hammering.

3.5 Pipe fittings

3.5.1 Piping connections shall be in accordance with relevant code or standard.

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

3.5.3 Joints of pipes with outer diameter of 51 mm and above shall, unless otherwise agreed, be made by butt-welding, flanged, or screwed union where the threads are not part of the sealing. Tapered threads and double bite or compression joints shall be justified on a case by case basis.

Guidance note:

Joints for smaller sizes, and which are not intended for corrosive fluids, may be welded or screwed and seal welded.

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

3.5.4 Threaded connections shall not be used in the following systems, if rated for high pressure:

- mud system
- choke and kill system
- cement system
- well test system
- other systems subject to bending or vibrational loads.

Guidance note:

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”. In general, threaded joints should not be used where subject to bending or vibrational loads.

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

3.5.5 Where expansion joints or bellows are fitted in the piping system, the piping shall be adequately adjusted, aligned, guided and anchored. Protection against mechanical damage shall be provided where necessary.

Guidance note:

See DNVGL-RP-D101 [3.10] for further details.

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

3.5.6 End connections which are not fully specified by a recognised standard (i.e. where the standard does not specify both dimensions and material requirements) shall be in accordance with the applicable normative reference for the system in which the end connection is intended to be installed.

Guidance note:

E.g. API Spec 6A for mud and cement, API Spec 16C for choke and kill systems. API Spec 16C should also be applied for well test systems.

See Table 2 for requirements to end connections when part of flexible hose.

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

3.6 Glass-reinforced plastic piping

3.6.1 Requirements in this subsection are also applicable for glass-reinforced epoxy (GRE) piping, fiberglass reinforced plastic (FRP) piping and similar.

3.6.2 Glass-reinforced plastic (GRP) piping shall be in accordance with ISO 14692 or equivalent.

3.6.3 Use of GRP piping shall be limited to open-to-atmosphere systems, e.g. drains and vent lines.

Guidance note:

Vertical vent lines in derrick structure should have a line-stop support on the lower part of the straight pipe designed to take the load from a vertical water filled (leak test) vent pipe.

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

3.6.4 GRP piping used to vent hydrocarbons shall be designed to handle H_2S, CO_2, etc.

3.6.5 GRP pipe support design shall minimize radial point loads on the GRP pipe wall.

3.6.6 GRP piping shall be earthed to avoid static electricity.

4 Piping supports

4.1 Support elements and penetrations

4.1.1 Piping supports shall be designed such that:

— distance between pipe supports prevents pipe sag that might result in liquid pockets

Guidance note:

Typically max. 6 mm (0.25") calculated sag/deflection for empty pipes.

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

— slope and drainage specified for the piping is achieved

— nozzle loads exerted on equipment from connected piping are within allowable nozzle load capacities

Guidance note:

See also [2.2.5].

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

— heavy piping components (e.g. valves, blocks) are supported on component body, or close to end connections

— piping can be assembled and maintained without requiring additional supports or introducing forces unaccounted for in the pipe stress and flexiblity analysis

— detrimental stresses due to vibrations will not occur in the piping system or be transferred to connecting equipment
— support stiffness values can be verified
— pipe stress levels are in compliance with ASME B31.3.

Guidance note:

Pipe supports should not deflect more than 3 mm under the given design loads.

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

4.1.2 Pipe supports shall not be welded directly to piping exposed to hydraulic hammering, vibration or high pressure.

Guidance note:

This will typically include high pressure mud systems, choke and kill systems, cement systems and well test systems.

Welded pipe supports for such piping, without reinforcement plate, may be accepted if conditions specified in [1.2] are taken into account and pipe stress and flexibility analysis proves compliance to ASME B31.3.

Particular attention should be made to local buckling/point loads where doubling plates are used for pipe support trunnions. See DNVGL-RP-D101 for guidance.

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

4.1.3 Gland type (stuffing box) penetrations through deck and bulkheads shall be applied in high pressure piping systems and/or piping systems providing essential or safety functions.

The stuffing box itself shall not be considered as being part of the load bearing structure/pipe support.

Guidance note:

For water tight bulkhead penetrations, see DNVGL-RU-SHIP Pt.4 Ch.6.

For fire protection, see DNVGL-OS-D301.

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

4.1.4 Design of hang-off supports at the interface between flexible hoses and MODU/OI structure (e.g. moon pool bulkhead) shall take all wave loads and other relevant environmental loads into account.

Guidance note:

Flexible riser analysis should be performed to establish design loads.

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

SECTION 4 ELECTRICAL, INSTRUMENTATION, CONTROL AND MONITORING SYSTEMS

1 Introduction

1.1 Scope

This section provides requirements for electrical, instrumentation, control and monitoring systems for important, essential and safety functions (as described in Sec.1 and Sec.5, Sec.6 and Sec.7).

2 Electrical systems

2.1 General

2.1.1 Electrical systems and components shall be according to DNVGL-OS-D201.

2.1.2 Power supply requirements to drilling facilities shall be in accordance with the principles provided in Sec.1, and detailed requirements for drilling systems and equipment as provided in Sec.5, Sec.6 and Sec.7.

2.1.3 If loss of main power occurs, it shall be possible to secure the well.

For OIs, and for MODUs which will maintain their location if loss of main power occurs (e.g. self-elevating or moored), it shall be possible to perform the following functions on emergency power, in relevant combinations:

— transfer and circulation of drilling fluids, (see Sec.7 [3.2.2])
— recharge BOP control system accumulators
— if the BOP has only one shear ram, not capable of shearing tool joints and sealing the well, it shall be possible to hoist or lower the drilling hoisting system to be able to shear the workstring
— adjust riser tension and heave compensation system (as applicable).

3 Instrumentation, control and monitoring systems

3.1 General

3.1.1 Instrumentation, control and monitoring systems and components shall be according to DNVGL-OS-D202.

Guidance note:

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

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

3.1.2 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].

Guidance note:

Other environmental conditions may be accepted, provided that the equipment supplied is suitable for the actual operating conditions identified. In this case, all contracting parties shall agree to the revised values.

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

3.1.3 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.

3.1.4 For systems providing safety functions or essential/important functions, deviations between a command action and expected result of the command action shall initiate an alarm.

3.1.5 Alarms shall be released and acknowledged at a defined control station (e.g. driller's cabin, toolpusher's office, central control room or other), as appropriate for safe operation of drilling systems and/or the MODU/OI.

3.1.6 When two or more safety functions are initiated by one failure condition (e.g. start of standby pump and stop of engine at low lubricating oil pressure), these functions shall be initiated sequentially, according to the safety philosophy (least drastic function shall be initiated first).

3.1.7 Radio remote controls and other wireless remote control systems shall comply with DNVGL-OS-D202 Ch.2 Sec.3 [3.5].

Systems/equipment providing essential or safety functions shall be provided with alternative means of control. Where emergency stop is required, an emergency stop independent of the wireless remote control shall be installed.

3.2 Field instrumentation

3.2.1 Field instrumentation belonging to separate systems/equipment providing essential or safety functions shall be independent.

3.2.2 If field instrumentation is common for several systems, and any of these systems is providing an essential/important or safety function, failure in any of these systems shall not affect this field instrumentation and vice versa.

3.2.3 Where local operation of an essential or safety function may be required, necessary field instrumentation with indications visible to operator shall be provided.

3.2.4 Electronic components that replace mechanical components shall have the same reliability as the mechanical component being replaced.

3.3 Integrated system

3.3.1 User input devices (UIDs) shall only be available at control stations.

3.3.2 Multifunction visual display units (VDU) and user input devices (UID) shall be redundant and interchangeable. The number of VDUs at control stations shall be sufficient to ensure that all functions can be provided with any one VDU out of operation, taking into account any functions which are required to be continuously available.

3.4 Power supplies

3.4.1 Power supply to instrumentation, control and monitoring systems supporting important, essential or safety functions shall be powered as required by DNVGL-OS-D201 Ch.2 Sec.2, including a transitional source of power/UPS.

3.4.2 UPS shall be monitored from a manned control station and have alarm if failure occurs.

Guidance note:

See DNVGL-OS-D201 App.A Table 1 for alarms.

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

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

SECTION 5 GENERAL REQUIREMENTS FOR DRILLING SYSTEMS

1 Introduction

1.1 General

1.1.1 This section provides general requirements for drilling systems.

Requirements shall be applied to all drilling facilities, as applicable to the type of system/equipment used.

Guidance note:

I.e. the requirements in this section are also applicable to systems/equipment described in Sec.6 and Sec.7.

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

1.1.2 Drilling systems are divided into Hoisting, rotating and handling systems and Well pressure and flow control systems with specific requirements provided in Sec.6 and Sec.7, respectively.

Guidance note:

Hoisting, rotating and handling systems are drilling systems related to hoisting, rotating, compensating and handling functions, while Well pressure and flow control systems are drilling systems ensuring pressure and flow control in the well.

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

1.1.3 Specific requirements for control and monitoring are grouped to the extent possible under each system.

Guidance note:

See also applicable requirements in Sec.1 and Sec.4.

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

1.1.4 Functions or systems for which requirements could vary depending on type of installation (e.g. OI, MODU, floating, DP operated, etc.) are specified under each drilling system in question.

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, see Ch.1 Sec.1 Table 4.

Guidance note:

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

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

2 Hazardous events

2.1 General

2.1.1 The requirements in this standard are results of hazard identification and barrier analysis, as introduced in Sec.1 [2].

In addition to the application of specific hazards (as provided in Sec.6 and Sec.7), drilling facilities contain some potential hazardous events which are relevant for most drilling systems. These are:

— accidental release of pressurized fluids
— personnel in contact with moving/rotating equipment
— personnel being hit by dropped objects
— electrocution.

2.1.2 Categorisation for operative barrier functions, and their corresponding safety functions (and systems, where relevant), shall be as provided in Table 1 for the hazardous events listed in [2.1.1].

Table 1 Barrier function categorisation

Operative barrier functions		*Corresponding safety function (system/equipment)*	*Related hazard*
Description	*Categorisation*		
Pressure containment - maintain structural integrity[1)]	Essential	2)	Accidental release of pressurized fluids
Avoid over-pressurization	Important	Relieve pressure (safety valves, blowdown system)	Accidental release of pressurized fluids
Avoid contact between moving/ rotating equipment and personnel	Important	Stopping operation (emergency stop). Avoiding contact (protection devices/guard/fence).	Moving/rotating equipment
Lifting equipment - maintain structural integrity	Essential	2)	Dropped objects
Avoid falling objects	Important	Avoid falling objects (securing arrangements)	Dropped objects
Avoid electrocution	Important	Prevent possibility for contact with electrically charged components (insulation, protection devices, etc.)	Electrocution

1) For fluids where pressure (bar) × volume (m^3) is above 1.5.

2) With respect to structural integrity, required safety and integrity may be obtained through design, manufacturing and maintenance of the operative barrier.

Guidance note:

For general requirements and descriptions of barriers, functions and systems, see Sec.1.

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

3 Arrangement and layout

3.1 General

3.1.1 Arrangement and layout of drilling facilities and its systems and equipment shall be arranged in accordance with the principles of DNVGL-OS-A101 Ch.2 Sec.2 and DNVGL-OS-A101 Ch.2 Sec.6 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.

3.1.3 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.

3.1.4 All systems and equipment that shall be operated, inspected or maintained on board shall be installed and arranged for safe and easy access.

3.1.5 Safe isolation shall be provided for all parts of drilling systems that contain pressurized 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.

Guidance note:

Two isolation valves should normally be installed.

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

3.1.6 Location and design of drilling systems providing essential/important or safety functions shall include due consideration of potential for dropped objects, especially in connection with materials and equipment handling.

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

Guidance note:

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

Equipment in areas where access is restricted when in use (e.g. choke & kill manifold), requirement to shielding or other permanent protection may be exempted.

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

3.1.8 The driller shall have a clear view of all activities at the drill floor and within drilling related structures during operation.

Guidance note:

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

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

3.2 Access and escape routes

See DNVGL-OS-A101 Ch.2 Sec.5 and DNVGL-OS-A101 Ch.2 Sec.6 for requirements to escape and escape routes, as well as specific requirements for stairs, ladders, handrails, etc. used in connection with access ways.

4 Fire and explosion

4.1 Active and passive fire protection

See DNVGL-OS-D301 Ch.2.

4.2 Ignition prevention

4.2.1 Machinery, electrical installations or other equipment necessary for the drilling operations (e.g. HPU) shall be suitable for the intended purpose and shall comply with the requirements of DNVGL-OS-A101 Ch.2 and DNVGL-OS-D201 Ch.2.

Guidance note:

For mechanical equipment located in 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, drilling hoisting braking system), greasing of wheels (e.g. dolly guide wheels), etc.

DNVGL-OS-A101 Ch.2 Sec.6 also contains specific requirements for drilling units (MODUs/OIs).

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

4.2.2 Electrical equipment and instrumentation that shall be operable during extended gas danger shall be Ex-certified 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:

E.g. active-heave compensation including brake resistors and 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 in the event of reduced ventilation or cooling, when necessary.

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

4.3 Ventilation

See DNVGL-OS-A101 Ch.2 Sec.3 and DNVGL-OS-A101 Ch.2 Sec.6.

4.4 Fire and gas detection

See DNVGL-OS-D301 Ch.2 Sec.4 and DNVGL-OS-A101 Ch.2 Sec.6.

5 Design loads

5.1 General

5.1.1 Drilling systems shall be designed to operate safely under relevant load combinations for specified drilling operational scenarios, and to limit the risk related to relevant hazards.

Guidance note 1:

While subsection [5] provides information on loads and load combinations, subsection [6] provides information for calculation of such loads for the specified load combinations.

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

Guidance note 2:

Where design loads and/or load combinations are not available, analysis should be used to identify these (e.g. low temperature downstream of chokes), to establish system/equipment design parameters.

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

5.1.2 Adequate margins shall be included in the prediction of loads and load combinations to establish required system/equipment design parameters.

5.1.3 All loads that might affect the functionality, safety, strength and reliability of the drilling facilities shall be considered.

5.1.4 Design loads shall include all relevant operating conditions, e.g. start-up, shutdown, and any other relevant condition which is likely to occur.

5.2 Environmental loads

5.2.1 Environmental criteria and motion characteristics used for design of the MODU/OI during applicable operating and non-operating conditions shall also be applied for design of drilling systems and equipment.

Guidance note:

Normally, the following design conditions should be evaluated (as applicable):

— operation
— survival
— transit
— waiting on weather (applicable for floating MODUs only)
— accidental.

See DNVGL-OS-C101 Ch.2 Sec.2 for further guidance.

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

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

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

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

— motion loads (i.e. heave, roll, pitch, sway, surge and yaw)
— wind loads
— air temperatures and humidity
— loads from possible accumulation of snow and ice
— earthquakes (not applicable for floating MODUs/OIs).

The remaining of this subsection provide further details on these loads.

5.2.5 Motion loads

5.2.5.1 Motion loads due to wind, current, and wave loads shall be included in the design loads for all special and primary structural members/mechanical equipment (e.g. pipe/riser handling equipment, BOP/XT handling cranes, derrick structure, etc.) and pressure containing equipment (e.g. separators, pressure vessels).

Guidance note:

Motion loads due to surge, sway and yaw are normally relatively small and may be neglected, provided that the greater of the conservative value combinations in [5.2.5.2] are considered for the actual location, and for all relevant modes (i.e. transit, operational and non-operational modes).

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.

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

5.2.5.2 The following value combinations for motion accelerations shall be applied:

— 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.

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

Guidance note:

Where motion characteristic is not available, conservative maximum pitch and roll accelerations of $\pm$0.35 g (at drill floor level, should be proportionally adjusted upward at higher levels) should be considered together with maximum heave acceleration of $\pm$0.3 g (excl. gravity) for non-operational mode (survival).

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

5.2.5.3 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.

5.2.6 Wind loads

5.2.6.1 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.

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

5.2.6.2 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, see DNVGL-OS-E301 Ch.2 Sec.1 [2.3].

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

5.2.7 Air temperature

Unless otherwise specified in this standard, 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.

Guidance note:

For marine equipment, see DNVGL-OS-D201 Ch.2.

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

5.2.8 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.

Guidance note:

Where location specific loading is not available, values as specified in DNVGL-OS-C101 Ch.2 Sec.2 may be used.

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

5.2.9 Earthquake loads

Where applicable, earthquake analysis shall be based on recognised standards and methods.

Guidance note:

See DNVGL-OS-C101 Ch.2 Sec.2, Eurocode 8 or similar.

Earthquake loads are not applicable for floating MODUs/OIs and are excluded from the scope of classification (see Ch.3 Sec.1 [2.4]).

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

5.3 Operational loads

5.3.1 Principal loads

The following shall be considered, as a minimum:

— loads due to the deadweight of the components (permanent loads).
  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 tension load, pressure, temperature, etc.)
— displacement loads (as applicable)
— loads due to pre-stressing of fasteners.

5.3.2 Vertical loads due to operational motions

5.3.2.1 The vertical loads due to operational motions shall be taken into account by multiplying the working load by a dynamic coefficient ψ.

Loads due to tension system hysteresis, eigenfrequency and dynamic amplification of motions (e.g. in BOP, riser, tension cylinders) shall be considered.

Guidance note:

Minimum values of ψ to be used in design calculations for specific equipment are found under respective sections of this standard.

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

5.3.2.2 For equipment with no specific value of ψ provided in this standard, the magnitude of ψ shall be in accordance with recognised codes or standards (as applicable).

Guidance note:

Values of ψ lower than those provided in this standard or in recognised codes or standards may only be applied where thoroughly demonstrated through testing, i.e. measurements of ψ during operation of the equipment under consideration.

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

5.3.3 Horizontal loads due to operational motions

All relevant horizontal loads shall be considered (as applicable).

Guidance note:

Examples 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 DNVGL-ST-0378 Sec.4.

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

5.3.4 Well fluid composition and specific weight

5.3.4.1 Design shall consider well fluid composition, taking into account corrosion, stress corrosion cracking, erosion, fouling, etc.

5.3.4.2 Unless otherwise specified, a specific drilling fluid weight of 2.1 t/m^3 shall be used as design basis for relevant equipment (e.g. mud tanks, riser tensioner etc.).

5.4 Accidental loads

5.4.1 Unless otherwise identified (e.g. from safety assessment or shelf-state requirements), the accidental loads provided in this subsection shall apply.

5.4.2 For floating MODUs/OIs, all equipment with potential to impair access or escape shall be capable to withstand an emergency static condition with the MODU/OI 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.

Unless means for emergency lowering of loads is provided, maximum operating loads shall be applied for the maximum inclination.

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 MODU/OI in damaged position. If these characteristics are not known, an additional static angle of 10° should be used.

The effect of other environmental loads (e.g. wind loads) need not be considered during this emergency condition.

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

5.4.3 Blast (explosion) loads shall be in accordance with DNVGL-OS-A101 Ch.2 Sec.1 [3.5].

The following shall be designed to withstand specific design overpressure and drag loads as specified for drilling rig in DNVGL-OS-A101 Ch.2 Sec.1 Table 1 and DNVGL-OS-A101 Ch.2 Sec.1 Figure 1:

— structures with the potential of blocking escape ways
— control lines for safety and essential functions
— structures supporting hydrocarbon containing equipment
— permanent hydrocarbon piping which can lead to escalation of incident.

Guidance note:

Explosion overpressure varies typically between 1.0-2.25 bar for an explosion volume of 10 000 m^3 and depends on shielding area. Explosion drag (wind) pressure can be set to 1/3 of overpressure, i.e. for an overpressure of 1.0 bar the blast drag wind pressure used for piping calculations become 0.33 bar. This equals a gust wind speed of 232 m/s, or 7 x Hurricane (7 x Beaufort 12) wind speed, hence the generic blast drag design load for piping and flexible lines can be significant compared with loads from accidental heel, etc.

See also DNVGL-RP-D101 [3.11].

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

5.4.4 Accidental loads shall include drive-off and drift-off scenarios (as applicable).

5.5 Loading combinations

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

— operational
— survival
— transit
— waiting on weather (applicable for floating MODUs only)
— accidental.

6 Design calculations

6.1 General

This subsection provides information for calculation of loads and loading conditions, as specified in subsection [5].

For each loading condition, and for each item to be considered, the most unfavourable combination, position, and direction of loads that might act simultaneously shall be used in the calculations/analyses.

6.2 Design safety factors

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

6.2.2 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. DNVGL-ST-0378 for structural and mechanical components, unless covered by other application code or standard.

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

6.2.3 Where safety factors refer to minimum specified yield strength of the material, the yield strength used in calculations shall not exceed 0.85 of the specified minimum tensile strength.

6.3 Modes of failure

6.3.1 Structural and mechanical components of the drilling system shall as a minimum be designed against the following possible modes of failure (as applicable):

— excessive yielding/displacement
— structural stability
— fatigue fracture.

6.3.2 Excessive yielding/displacement

Stress analysis shall, unless otherwise agreed, be based on elastic theory.

Guidance note:

An ultimate strength (plastic) analysis may be used where appropriate.

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

6.3.3 Structural stability

Stability analysis shall be carried out according to generally accepted theories, as provided in relevant normative references.

Guidance note:

Unless otherwise specified, reference is made to EN 1993-1 Eurocode 3. Alternatively API RP 2A or ANSI/AISC 360 may be used, in combination with DNV-RP-C201 for plated structures.

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

6.3.4 Fatigue

6.3.4.1 Areas of components that are susceptible to fatigue damage shall be evaluated.

6.3.4.2 Structures with slender members that are exposed to direct wind/current loading, shall be documented as able to withstand possible wind/current induced vibrations (vortex induced vibrations (VIV)).

6.3.4.3 Fatigue evaluation shall be based on the drilling system design life.

Guidance note:

For drilling system design life, see Sec.1 [3.2.1.2].

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

6.3.4.4 Fatigue evaluation 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 facilities. If this approach is used, the effect of directional spreading of the environmental loads should not be used in the fatigue evaluation.

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

6.3.4.5 For structural members and mechanical components, a design fatigue factor (DFF) against fatigue failure shall be included in the fatigue evaluation.

Unless a higher DFF is given in the applicable reference standard, the following shall apply:

— If the consequence of failure is low, the DFFs provided in DNVGL-OS-C101 Ch.2 Sec.5 Table 1 shall be applied.
— If the consequence of failure is high, and the part is available for inspection, maintenance and repair, the DFF shall be 3.
— If the consequence of failure is high, and the part is not available for inspection, maintenance and repair, the DFF shall be 10.

7 Emergency stops

7.1 General

7.1.1 For general requirements to emergency stops, see DNVGL-OS-D201 Ch.2 Sec.2.

7.1.2 Emergency stops shall be located at control stations and at convenient location(s) near machinery for immediate use by personnel in the event of a hazardous situation occurring.

Guidance note:

Emergency stop only on control stations may be sufficient where control stations are located near machinery.

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

7.1.3 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.

7.1.4 Emergency stops shall function according to one 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) and then removal of power when the stop is achieved.

Upon activation, the emergency stop 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.

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

7.1.5 Emergency stops shall, as a principle, overrule all other functions, unless an alternative approach is deemed safer and thoroughly justified.

Emergency stops shall not be in conflict with the fail-safe philosophy, see Sec.1 [3.2.2].

7.1.6 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/electric 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.

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

7.1.7 When an emergency stop is not hardwired, self-check facilities according to Sec.1 [3.2.2.3] shall be implemented.

7.1.8 Emergency stops shall be clearly marked.

Guidance note:

E.g. according to ISO 13850.

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

8 Equipment at height

Equipment installed above drill floor, moon pool or other normally manned area, 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.

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

9 Hydraulic and pneumatic systems

9.1 General

9.1.1 This subsection applies to hydraulic and pneumatic systems providing or supporting essential, important or safety functions.

9.1.2 Hydraulic or pneumatic equipment shall be fitted with safety valves.

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

Guidance note:

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

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

9.1.4 Unintentional leakage from detachable pipe connections, valves, hose rupture etc. shall not endanger the safety of personnel or MODU/OI.

Guidance note:

E.g. protective covers on hoses situated near operator's stations in event of hose rupture, hose rupture valves in systems providing safety, essential or important functions(as applicable), ignition sources at a safe distance from potential leakage sources of flammable hydraulic liquid systems, etc.

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

9.1.5 Systems requiring high availability 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 locked-to-bottom operations.

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

9.1.6 Local accumulators which are used as back up supply for essential or safety functions shall be designed and located or protected to avoid inadvertent isolation or mechanical damage which could prevent correct operation on demand.

9.2 Hydraulic systems

9.2.1 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.

See also Sec.3 for design requirements for piping components. For components not covered by this section, see normative references in Ch.1 Sec.1 [3].

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

9.2.2 Hydraulic cylinders for lifting, tensioning or heave compensation systems shall be according to DNVGL-CG-0194.

9.2.3 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.

SECTION 6 HOISTING, ROTATING AND HANDLING SYSTEMS

1 Drilling related structures

1.1 Introduction

1.1.1 Drilling related structures shall provide support for drilling systems and equipment.

1.1.2 This subsection describes requirements for drilling related structures including equipment, such as, but not limited to:

— derricks
— hoisting towers
— drill floor
— substructure
— lifting lugs, skids and brackets.

1.1.3 Drilling related structures shall be capable of supporting the prevention of relevant hazardous events from occurring. If occurred, the structures shall support the mitigation of the consequences of such an event.

The following hazardous events are considered in this subsection:

— dropped load
— blowout.

1.1.4 Drilling related structures are categorized as special area (for essential and safety functions), primary (for important functions) and secondary (for less-important functions).

Guidance note:

As structures normally do not have a safety barrier in case of failure, the required safety level may be met through the operative barrier and its performance requirements, ensuring robust design towards all relevant failure modes (i.e. by applying recognised design codes, appropriate safety factors, etc.).

For general requirements and description of barriers and functions, see Sec.1. For definitions, see Ch.1 Sec.1.

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

1.2 General

1.2.1 Structures and components shall be designed in accordance with recognised codes, standards and guidelines.

1.2.2 Structures and components 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.

1.2.3 Relevant loads and loading combinations for calculation of structural strength shall be specified in accordance with Sec.5 [5] and Sec.5 [6].

1.2.4 Access and escape routes shall be in accordance with Sec.5 [3.2].

1.2.5 All drilling structures shall have marking which includes basic design limitations.

Guidance note:

E.g. for derrick marking see API Spec 4F.

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

1.2.6 Pre-tensioned friction connections

1.2.6.1 Slip-coefficient shall be obtained by testing. Test samples shall reflect materials, coatings and bolting procedures as applicable.

1.2.6.2 Bolt pre-loading procedure shall be established by the manufacturer. All factors affecting correct torque application shall be properly addressed.

1.3 Drilling structures

1.3.1 Standard derrick design for which the hook load is transferred through the derrick structure shall be according to the requirements of API Spec 4F, subject to additional considerations as per Sec.5 [5] and Sec.5 [6] (as applicable).

Environmental loads shall be according to rig specifications. Associated wind loads shall be calculated according to the applied offshore standard for structures (e.g. DNVGL-OS-C101 Ch.2).

1.3.2 Other designs of drilling structures not covered by API Spec 4F, shall be thoroughly evaluated for all applicable loads and loading combinations as listed in Sec.5 [5] and Sec.5 [6]. Relevant items, as in [1.3.1], shall also apply.

1.3.3 Effective shape coefficient for calculation of wind loads on pipe stands (solidification effect) shall be calculated according to DNV-RP-C205 Sec.5 or equivalent.

1.3.4 Walkways, ladders, etc. shall be in accordance with DNVGL-OS-A101 Ch.2 Sec.5 and DNVGL-OS-A101 Ch.2 Sec.6.

1.3.5 Lighting and other electrical equipment in derrick shall either be Ex-certified or tripped on gas detection on drill floor, or any other relevant location.

1.4 Drill floor

1.4.1 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.5 [5.4].

Guidance note:

See DNVGL-RU-OU-0101 Ch.2 Sec.2 for further requirements to drill floor.

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

1.4.2 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.

1.4.3 Relevant combinations of operational and environmental loads as outlined in Sec.5 [5] and Sec.5 [6] shall be specified for all relevant loading conditions.

Setback loads shall be specified at 100% for operation, accidental and unexpected storm conditions.

Setback loads shall be specified at 100% for survival conditions, unless a reduction is justified.

Guidance note:

Time constraints do not normally allow for reducing setback loads.

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

1.4.4 The drill floor shall be designed, as a minimum, to withstand the impact from a falling 9 1/2" drill collar stand from a height of 1.5 m.

1.5 Substructure

Substructure shall be designed to withstand all combined loads as outlined in Sec.5 [5].

Guidance note:

See DNVGL-RU-OU-0101 Ch.2 Sec.2 for further requirements to substructure.

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

1.6 Support structure for drilling or well testing equipment

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

1.6.2 Flare boom structure shall be designed for loads in both operating and stowed condition.

1.6.3 Design of the flare or burner boom structure shall include considerations of thermal loads during flaring.

1.7 Lifting of equipment

1.7.1 The intention of this subsection is to provide design requirements for equipment subject to regular lifting (including maintenance), and to provide guidance for installation lifting (as applicable).

1.7.2 Design of lifting lugs/brackets shall specify maximum sling angle and include resulting stresses in the design calculations.

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

1.7.4 Skids, spreader beams and lifting lugs/brackets intended for regular lifting

1.7.4.1 Design of lifting skids, spreader beams and lifting lugs/brackets shall be in accordance with a recognised standard.

1.7.4.2 Special areas/primary structural members, including lifting brackets, shall be welded with full penetration welds. Welds which are perpendicular to the direction of applied fluctuating stresses in members important to the structural integrity shall, unless otherwise agreed, be full penetration type and, if possible, welded from both sides.

Guidance note:

Dressing of welds by grinding may be required.

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

1.7.4.3 For marking of lifting lugs/brackets which might be used for 2-fall applications, see DNVGL-ST-0378 App.B.

1.7.5 Skids, spreader beams and lifting lugs/brackets intended for installation lifting only

Design of lifting skids, spreader beams and lifting lugs/brackets used during installation lifting 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 provided in Table 1 should be applied:

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

2 Drilling hoisting and rotating systems

2.1 Introduction

2.1.1 Drilling hoisting and rotating systems shall safely hoist, lower, stop and hold the maximum allowable load, rotate drill string and allow for drilling fluid circulation.

2.1.2 This subsection describes requirements for hoisting and rotating systems, including equipment such as, but not limited to:

Drilling hoisting systems

— drawworks
— electric hoisting system
— hydraulic hoisting system
— rack & pinion hoisting system
— crown block or structural parts of compensators
— travelling block
— drilling hook, yoke and/or adapter
— guide dollies
— elevators
— elevator links
— running tools
— drill line anchor
— drill line

— braking resistors.

Rotating systems

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

2.1.3 Drilling hoisting and rotating systems shall be capable of preventing, or support the prevention of, relevant hazardous events from occurring.

The following hazardous events are considered in this subsection:

— blowout
— dropped load.

2.1.4 Categorisation for operative barrier functions, and their corresponding safety functions (and systems, where relevant), shall be as provided in Table 2 for hazardous events listed in [2.1.3].

Table 2 Barrier function categorisation for drilling hoisting and rotating systems

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		
Braking (stop and hold load)	Important	Braking (emergency braking system)	Dropped load
Maintain structural integrity	Essential[1)]	[1)]	Dropped load
Hoist or lower for pipe ram closing (space out) and tubular hang-off	Important	Shut in well (WSD system)	Blowout
Hoist or lower workstring to avoid tool joint (if only one BSR)	Important	Emergency lowering	Blowout
Pull out workstring after shearing, to allow BSR closing on open hole (if possibility of hitting tool joint with BSR exists)	Important[2)]	[2)]	Blowout

1) With respect to structural integrity, required operative performance, safety and integrity may be obtained through design, manufacturing and maintenance of the operative barrier. See also Sec.1.

2) Pull out of workstring may be achieved by activation of BSR after disconnect has been completed (autoshear), through relocation of MODU, stroking out with passive compensators, etc.

Guidance note:

For WSD systems, see Sec.7 [4].

For general requirements and description of barriers and functions, see Sec.1.

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

2.2 Drilling hoisting systems - general

2.2.1 The rated capacity of a drilling hoisting system shall refer to the system rating specified at:

— top drive/power swivel drill stem (the drilling hoisting system capacity at the main shaft lower connection)

— top drive/power swivel link hanger (the drilling hoisting system capacity of the link hanger when handling loads through links).

The capacities shall be defined by the weakest component in the drilling hoisting system, considering the weight of all supported components.

2.2.2 Drill stem rating for drilling hoisting systems and components shall be defined by maximum operating load, both static and dynamic, resulting from any relevant combination of hoisting, rotation and circulation.

2.2.3 Drill stem load path, as covered by this standard, shall be extended from the rating reference point, to also include spacer sub and top drive safety valves.

If rotary shouldered connection in the top drive safety valve is subjected to hoisting loads other than drill stem loads (e.g. lift/tension frames), the application of this standard shall also cover such equipment.

2.2.4 Link hanger load path, as covered by this standard, shall be extended from the rating reference point, to also include elevator links, elevators, running tools, etc.

If link hanger will support loads from other equipment than those mentioned (e.g. loads from lift/tension frame, circulating head, etc.), the application of this standard shall also cover such equipment.

Guidance note:

Equipment supported in the link hanger (e.g. links, elevators, running tools, circulating heads, lift frames etc.) and the rotary shouldered connection (e.g. spacer sub, top drive safety valves, etc.) may have a lower rating than the drilling system rating and as such be a limiting factor with respect to available operating capacity.

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

2.2.5 Brakes

2.2.5.1 Drilling hoisting systems shall be provided with the following braking systems:

— operative braking system, (see [2.3.1] to [2.3.3])
— emergency braking system, (see [2.4.1] to [2.4.4]).

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

Guidance note:

Brake discs should have protection against spillage of oil from the brake calipers or wire lubricants onto the brake disc.

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

2.2.5.3 Calculation of minimum required braking capacity shall be based on the most challenging operational scenario and the worst allowable brake conditions.

Guidance note:

For caliper brakes, worst allowable brake conditions would imply that the springs are worn, the air gap is at its maximum due to wear, the caliper normal force is at its minimum estimate, the friction coefficient is at its minimum estimate, etc.

Coefficient of friction should normally not be taken higher than 0.3, unless justified by appropriate testing.

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

2.2.5.4 Brakes relying on mechanical friction shall be provided with a test mode to allow for verification of the minimum required braking capacity.

2.2.5.5 Structural and mechanical components of the braking system, including necessary utilities, shall be designed to handle maximum anticipated loading. Maximum braking force shall never cause stresses, which exceed the allowable, in the drilling hoisting system or the drilling structure. Static and dynamic contributions from both translational and rotational motions of load and components shall be considered, in addition to block efficiency effects (as applicable).

2.2.6 Wire ropes

2.2.6.1 Unless more stringent requirements are found in this standard or other applied reference code or standard, the safety factors of wire ropes shall be as per 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.

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

Guidance note:

Clamping device designs should be according to appropriate recognised code or standard.

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

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

2.2.7 Sheaves

2.2.7.1 Sheaves and sheave blocks shall be designed to prevent wire rope running off the sheave.

2.2.7.2 Non-welded sheaves are normally exempted from impact testing, unless required by applied code or standard.

2.2.7.3 Nodular cast iron used for sheaves shall have a minimum elongation of 10%.

Guidance note:

See DNVGL-OS-B101 Ch.2 Sec.1 [3] for test types and dimensions.

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

2.3 Drilling hoisting systems - operative functions/systems

2.3.1 The operative braking system shall have functional capabilities to safely lower and stop the maximum allowable load at corresponding maximum allowable speed, or any other specified load/speed combinations.

The operative braking system shall have functional capabilities to hold maximum rated load.

2.3.2 Mechanical brakes, if used for holding (parking brake), shall have a minimum capacity of 1.33 times the capacity required to hold maximum rated load.

2.3.3 Electric motors, if used for holding, shall be able to hold maximum rated load, without exceeding rated capacity for relevant duty cycle.

2.3.4 Drawworks

2.3.4.1 For drawworks drums with simple type cylinder designs, the hoop stress (σ_h) in the barrel shall not exceed 85% of the specified minimum material yield stress, where:

$$\sigma_h = C \times \frac{S}{p \times t_{av}}$$

σ_h	=	calculated hoop stress in drum barrel
S	=	maximum 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.

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

The requirement regarding different C–values might 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 drawworks, means shall be provided to monitor the actual number of wire layers spooled on the drum.

Guidance note:

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

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

2.3.4.2 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:

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

The calculated flange stress shall not exceed 85% of the specified minimum material yield stress.

p_f	=	pressure on drum flanges
t_{av}	=	average wall thickness of drum barrel
D	=	outer diameter of the barrel
σ_h	=	calculated hoop stress in drum barrel.

2.3.5 Control and monitoring

2.3.5.1 Necessary condition monitoring of the system shall be provided and be available at the control station to detect and alarm abnormal conditions that might lead to loss of essential or important functions.

Guidance note:

Monitoring of the following should be considered, as applicable:

- anti-collision
- slack-wire detection
- failure in the hoisting system
- for 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.

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

2.3.5.2 The following parameters shall be indicated at the control station:

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

2.3.5.3 Any system failure that might lead to loss of essential or important functions shall initiate alarm and automatically enter the hoisting system into the safe state relevant for each particular mode of operation.

Guidance note:

E.g. tripping of el-motors caused by heat, overload etc. should automatically activate brakes if in ordinary drilling mode, but not if locked-to-bottom mode.

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

2.3.5.4 If hoisting system is moving without command (e.g. by joystick, automated systems, etc.), the hoisting and lowering shall be stopped automatically.

This shall not apply for hoisting systems providing active heave compensation, if in compensating mode.

2.4 Drilling hoisting systems - safety functions/systems

2.4.1 The drilling hoisting system shall be equipped with a readily identifiable and accessible emergency braking system for use in the event of any failure in the operative braking system. The emergency braking system, including its controls, monitoring and utilities, shall be independent of the operative braking system and shall have functional capabilities to stop, hold and safely lower the load.

2.4.2 The emergency braking system shall have capacity to stop any allowable combination of speed and load, with brakes in worst allowable condition, within 75% of specified maximum stop distance.

2.4.3 Calculation of the specified maximum stop distance shall be based on the documented worst case scenario, i.e. considering both the most critical combination of translational and rotational motions using minimum allowed braking capacity, and including the time delay from when the emergency braking system is activated and until it is fully engaged.

2.4.4 Combined static and dynamic forces acting on the hoisting system during braking, with brakes in best possible condition, shall neither induce loads exceeding rated capacity of the system, nor stress in any component of the hoisting system which exceed maximum allowable stress.

2.4.5 A safety function/system shall be installed, preventing the travelling equipment from accidentally being run into the drill floor (floor saver) or crown block (crown saver) by activating the emergency braking system.

Floor saver available stop distance shall not be less than the specified maximum stop distance, see [2.4.3].

Guidance note:

The safety function may be activated by the operative system, provided the control and monitoring system meets the requirement for R0, as described in Sec.1 [3.2.3].

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

2.4.6 Override of floor/crown saver shall enter the drilling hoisting system into creep mode (low speed).

2.4.7 If anti-collision functionality is provided, and when possible collision is detected, the hoisting system shall automatically enter the safe state.

Guidance note:

See Sec.1 [3.4.1.7].

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

2.5 Rotating systems - operative functions/systems

2.5.1 The following parameters shall be monitored and indicated at the control station:

— rotating speed and torque
— torque wrench set point and achieved torque.

2.5.2 Top drive electric motors shall have an ingress protection grade that is suitable for the intended use and location.

Guidance note:

IP 44 will under normal conditions be sufficient.

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

3 Heave compensation and tensioning systems

3.1 Introduction

3.1.1 Heave compensation systems shall provide drill string compensation for heave movements, while tensioning systems shall provide specified tension while allowing for heave compensation.

3.1.2 This subsection describes requirements for heave compensation and tensioning systems, including equipment such as, but not limited to:

— marine riser tensioners, including recoil system
— conductor tensioners/BOP tensioners
— guideline tensioners/tension winch
— podline tensioners/tension winch
— idler sheaves
— heave motion compensators (including compensating drilling hoisting systems)
— pressure vessels
— control and monitoring.

3.1.3 Heave compensation and tensioning systems shall be capable of preventing, or support the prevention of, relevant hazardous events from occurring. If occurred, the system shall mitigate, or support the mitigation of, the consequences of such an event.

The following hazardous events are considered in this subsection:

— blowout
— dropped object
— impact due to riser recoil.

3.1.4 Categorisation for operative barrier functions, and their corresponding safety functions (and systems, where relevant), shall be as provided in Table 3 for the hazardous events listed in [3.1.3].

Table 3 Barrier function categorisation for heave compensation and tensioning systems

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		
Compensate workstring to facilitate shearing	Important	Shut in well (WSD system)	Blowout
Compensate workstring during locked-to-bottom operations (e.g. well testing)	Important	Shut in well (WSD system)[1)]	Blowout
	Essential[2)]	Prevent/control mechanical failure[3)]	Dropped object
Stroke out cylinders on passive compensators after shearing workstring, to facilitate BSR closing on open hole (if required to avoid hitting tool joint)[4)]	Important	Shut in well (WSD system)[4)]	Blowout
Prevent uncontrolled stroke out of passive cylinders, e.g. due to drill string failure	Important	Decelerate drill string movement (flow restriction valve)	Dropped object
Maintain riser tension for riser disconnect	Essential	Shut in well (WSD system)	Blowout
Avoid impact between riser and rig during riser disconnect	Important	Decelerate riser movement (Anti-recoil system)	Impact due to riser recoil
Maintain structural integrity	Essential[5)]	[5)]	Dropped load

1) Assume shearable tubulars.
2) Allow for maintained compensation by e.g. passive compensator, stored power for active system, limit operation to be within stretch limits, etc.
3) E.g. in-line compensator may be considered.
4) See Table 2, footnote 2.
5) With respect to structural integrity, required operative performance, safety and integrity may be obtained through design, manufacturing and maintenance of the operative barrier. See also Sec.1.

Guidance note:

For WSD systems, see Sec.7 [4].

For general requirements and description of barriers and functions, see Sec.1.

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

3.2 General

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

3.2.2 Loss of power shall not lead to loss of safety or essential functions.

Guidance note:

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

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

3.2.3 Hydraulic cylinders shall be designed both for internal pressure loads, for loads resulting from their function as structural members (including possible lateral loads), and shall comply with the requirements in Sec.5 [9.2.2].

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

3.2.5 Podline and guideline winches which are to be used for lifting operations shall comply with requirements for winches in [6].

3.2.6 Safety functions/systems

3.2.6.1 Air control panels, pressure vessels and accumulators shall be fitted with safety valves.

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

3.3 Heave compensation systems

3.3.1 Operative functions/systems

3.3.1.1 Necessary condition monitoring of the system shall be provided and be available at the control station to detect abnormal conditions that might lead to loss of essential or important functions. 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)
— monitoring of hydraulic holding pressure on the individual brake calipers for locked-to-bottom (LTB) operations with active heave drawworks.

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

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

3.3.2 Safety functions/systems

3.3.2.1 Restricted flow in compensators shall be arranged to safeguard against high velocity of pressurised fluid, e.g. due to drill string failure, wire rupture, hose rupture, etc.

Guidance note:

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

For LTB operations, consequences of unintentional closing of the flow restriction valve can be severe. Probability reducing measures should therefore be considered, by e.g. having the flow restriction valve(s) locked open during LTB operations.

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

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

Guidance note:

This applies to e.g. active heave compensated drawworks used in locked-to-bottom operations, where additional means of safety may be a deadline/in-line compensator, weak link, etc.

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

3.4 Riser tension systems

3.4.1 Operative functions/systems

The requirement of single failure in [3.2.1] also applies with one riser tensioner line removed.

3.4.2 Safety functions/systems

3.4.2.1 MODUs with marine drilling risers shall be fitted with an anti-recoil system or equivalent.

3.4.2.2 Anti-recoil systems shall be designed to prevent any uncontrolled upward motion of the riser that may cause an impact with the MODU, and subsequent damage and hazard to personnel.

3.4.2.3 Anti-recoil systems shall be operable after an ESD.

4 Handling systems

4.1 Introduction

4.1.1 Handling systems shall safely handle tubulars, tools and equipment.

4.1.2 This subsection describes requirements for handling systems, including equipment such as, but not limited to:

— tongs, grippers, magnets
— horizontal pipe/riser handling
— vertical pipe/riser handling
— BOP- and XT-handling (including trip saver functionality, where installed).

4.1.3 Handling systems shall be capable of preventing, or support the prevention of, relevant hazardous events from occurring. If occurred, the system shall mitigate, or support the mitigation of, the consequences of such an event.

The following hazardous event is considered in this subsection:

— dropped load.

4.1.4 Categorisation for operative barrier functions, and their corresponding safety functions (and systems, where relevant), shall be as provided in Table 4 for the hazardous event listed in [4.1.3].

Table 4 Barrier function categorisation for handling systems

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		
Control load at height (lifting appliances)	Important	Stop, hold and lower/secure load (Emergency braking system, Emergency lowering)	Dropped load
Control load at height (e.g. over moon pool) (non-lifting appliances)	Important	Secure load[1)]	Dropped load
Maintain structural integrity (lifting and non-lifting appliances)	Essential	1)	Dropped load

1) With respect to structural integrity, required safety and integrity may be obtained through design, manufacturing and maintenance of the operative barrier.

Guidance note:

For general requirements and description of barriers and functions, see Sec.1.

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

4.2 General - Operative functions/systems

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

4.2.2 Tongs

4.2.2.1 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.

4.2.2.2 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.

4.2.2.3 Failure of the torque sensor shall not lead to loss of essential or important functions.

Guidance note:

E.g. use of two sensors with failure detection and alarm.

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

4.2.3 Grippers

4.2.3.1 Grippers where frictional forces are required to prevent the load from dropping shall be designed to hold an equivalent of 2 × 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).

Holding power shall be verified through testing.

Guidance note:

Testing of gripper capacity should preferably be done during testing before delivery. This test should not be confused with load testing of the lifting appliance.

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

4.2.3.2 Grippers shall be protected from potential destructive loads that could occur if a gripper with associated load is unintentionally operated/forced downwards into deck/floor during pick-up or lay-down.

Guidance note:

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

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

4.2.3.3 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.

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

4.2.3.4 Considerations shall be made to prevent that operator error or control system failure leads to dropped load.

Sec.4 shall apply, unless the gripper function is activated independently of the control system (hardwired).

Guidance note:

To protect against possible operator error, two signals from operator may be required to activate opening of gripper.

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

4.2.4 Magnets

4.2.4.1 To ensure sufficient holding capacity for all operational conditions, magnets shall be designed to hold 3 × SWL at normal operating conditions.

4.2.4.2 Holding power for ideal conditions is dependent on type of material, size (diameter or wall thickness) and mass. Holding power shall therefore be verified through testing for each combination of these parameters for the pipes/risers intended to be lifted.

4.2.4.3 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.

4.2.4.4 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.

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

4.2.4.5 Considerations shall be made to prevent that operator error or control system failure leads to dropped load.

Sec.4 shall apply, unless the magnet function is activated independently of the control system (hardwired).

Guidance note:

To protect against possible operator error, two signals from operator may be required to deactivate the magnets.

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

4.3 General - Safety functions/systems

4.3.1 Necessary means shall be provided for emergency manoeuvring of each lifting appliance (including load) to a safe stowed position.

4.3.2 Necessary means shall be provided for securing of each non-lifting appliances (including load).

4.3.3 Unless otherwise justified, it shall be possible to complete emergency manoeuvring within 10 minutes of the start of the emergency.

4.3.4 Emergency stops shall be implemented in accordance with Sec.5 [7].

4.3.5 Tongs

4.3.5.1 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.

4.3.5.2 Power tong pressure systems shall be equipped with safety relief valve.

4.3.6 Grippers

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, until load has been landed or secured.

Guidance note:

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

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

4.4 Horizontal pipe- and riser handling systems

4.4.1 Operative functions/systems

4.4.1.1 Structural design of horizontal pipe/riser handling equipment shall include consideration of all relevant loadings, including motion loads (as applicable), see Sec.5 [5].

The dynamic coefficient ψ shall be in the range 1.3 to 1.6 depending on type of design.

Guidance note 1:

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. DNVGL-ST-0378 for further details.

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

Guidance note 2:

Horizontal pipe/riser handling includes transportation within the pipe and riser deck areas, as well as transportation between pipe and riser deck areas and drill floor.

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

4.4.1.2 Access to operating areas shall be clearly restricted during equipment operation.

Guidance note:

This will normally include proper enclosure, visual and/or audible warnings. This is particularly important for systems having automated functions (e.g. automatic return to standby position upon delivery of pipe/riser).

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

4.4.2 Safety functions/systems

If access to operating areas 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 functions provided for vertical pipe and riser handling in [4.5.2] apply.

4.5 Vertical pipe- and riser handling systems

4.5.1 Operative functions/systems

4.5.1.1 The requirements in [4.4.1.1] apply.

Guidance note:

Vertical pipe/riser handling includes equipment such as racking board, standlift arrangement, stand guide arrangement and make-up or break-out arrangement.

Equipment such as stabbing boards and baskets are regarded as manriding equipment (see [5]).

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

4.5.1.2 There shall be provisions for storage of drill pipe collars, tubing, rods, and casing (as relevant).

4.5.1.3 Storage racks shall be designed to prevent drill collars, pipe, risers and other tubular material from accidentally being released from the rack (e.g. due to tubular dynamic behaviour as a result of wind loading and/or motion loads).

4.5.2 Safety functions/systems

4.5.2.1 Drill floor area shall be regarded as permanently manned, and thus special safety features are required to safeguard personnel, unless access can be restricted (e.g. for remote/automated drilling processes). In particular, the potential for accidents and injuries resulting from single failure shall be avoided.

Interlocks shall be implemented where needed.

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

4.5.2.3 If unintended collisions might be caused through automated operations, means shall be implemented as necessary to avoid unintended collisions, e.g. between top drive and racking arms.

Guidance note:

E.g. by means of anti-collision system or interlocks.

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

4.5.2.4 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 lowering to safe location.

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

4.6 BOP- and XT handling systems

4.6.1 Operative functions/systems

4.6.1.1 Design of BOP- and XT carriers or skids shall take into account relevant loads induced by the maximum operational and survival conditions, including maximum static heel (as applicable). Securing arrangements during operational and survival conditions shall also be taken into account.

If hang-off functionality is provided (e.g. trip-saver), drag forces and added mass shall also be considered.

4.6.1.2 BOP- and XT guiding systems, including wire rope guidelines, shall take into account operational and accidental conditions.

5 Man-riding equipment

5.1 Introduction

5.1.1 Man-riding equipment shall allow for safe man-riding operations.

5.1.2 This subsection describes requirements for man-riding equipment, such as, but not limited to:

— man-riding winches
— stabbing boards
— access baskets
— mobile lifting platforms (e.g. scissor lifts).

Guidance note:

For the purpose of this standard, man-riding equipment includes lifting appliances intended for lifting of personnel, and having a height of fall above 3 m.

Lifts are excluded, see applicable regulations for the MODU/OI the lift will be installed on. If the lift is to be certified by DNV GL, DNV GL's *Certification of lifts in ships, mobile offshore units and offshore installations* will normally apply.

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

5.1.3 Man-riding equipment shall be capable of preventing, or support the prevention of, relevant hazardous events from occurring. If occurred, the equipment shall mitigate, or support the mitigation of, the consequences of such an event.

The following hazardous event is considered in this subsection:

— harm to personnel.

5.1.4 Categorisation for operative barrier functions, and their corresponding safety functions (and systems, where relevant), shall be as provided in Table 5 for the hazardous event listed in [5.1.3].

Table 5 Barrier function categorisation for man-riding equipment

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		
Stop and hold load	Important	Stop and hold load (Emergency brake)	Harm to personnel
Lower or hoist load	Important	Lower or hoist load (Emergency lower/hoist)	Harm to personnel
Maintain structural integrity	Essential	1)	Harm to personnel

1) With respect to structural integrity, required safety and integrity may be obtained through design, manufacturing and maintenance of the operative barrier.

Guidance note:

For general requirements and description of barriers and functions, see Sec.1.

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

5.2 General

5.2.1 Operative functions/systems

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

5.2.1.2 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.

5.2.1.3 The following loads shall be included in the design of man-riding equipment (as applicable):

Table 6 Loads to be considered

Load	*Description*
$2 \times S_L \times \psi_L$	S_L = live load, vertical (SWL x g)
	ψ_L = dynamic factor due to vertical motion of live load
$m_L \times a_{LH}$	m_L = lifted mass (SWL)
	a_{LH} = maximum acceleration due to horizontal motion of lifted mass (SWL)
$S_G \times \psi_G$	S_G = self-weight of the lifting equipment (m_G x g)
	ψ_G = dynamic factor due to vertical motion of lifting appliance

Load	*Description*
$m_G \times a_{GH}$	m_G = mass of lifting equipment
	a_{GH} = maximum acceleration due to horizontal motion of lifting appliance
S_W	wind loads
S_M	inertia loads due to motion of the vessel

Safety factors according to design code shall be applied to the calculations.

Dynamic factors shall be according to design code.

Guidance note:

Dynamic factors taken from actual testing might be accepted.

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

5.2.1.4 Machinery systems lifting personnel shall be fitted with two separate independently operated braking systems, the operating brake and the emergency brake.

The operating brake shall be capable of stopping and holding the load upon activation.

Where cylinders are used for luffing, folding or telescoping, they shall be provided with a hydraulic shut-off valve.

Guidance note:

See DNVGL-ST-0378 [11.5.1.6].

For emergency brake, see DNVGL-ST-0378 [5.2.2.1] .

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

5.2.1.5 The potential for accidents and injuries resulting from single failure shall be avoided.

Guidance note:

Including evaluation of e.g. single failures for hardware of the computer based system, sensors, actuators and associated cables, computer software, and operator error.

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

5.2.1.6 Platforms, ladders and other access routes associated with entering the man riding device, shall comply with recognised safety standards or regulations.

5.2.1.7 If brakes relying on mechanical friction are fitted, they shall comply with [2.2.5.2].

5.2.2 Safety functions/systems

5.2.2.1 The emergency brake shall be capable of stopping and holding the load upon activation. Where cylinders are used for luffing, folding or telescoping, they shall be provided with a hydraulic shut-off valve.

Guidance note:

See DNVGL-ST-0378 [11.5.1.6].

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

5.2.2.2 Lines where hose rupture might lead to loss of essential or important functions (e.g. casing stabbing basket) shall be fitted with a hose rupture valve or equivalent means of protection against uncontrolled lowering.

5.2.2.3 Wire-fitted systems where slack wire might lead to loss of essential or important functions 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 by the operator, i.e. the detection system shall automatically re-activate when operator is no longer present at the winch.

5.3 Control and monitoring

5.3.1 Operative functions/systems

5.3.1.1 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 (including operative and emergency braking) shall neither injure nor harm personnel being transported.

5.3.1.2 Control stations for man-riding equipment shall include all necessary devices for normal operation of equipment, including emergency stops. Control stations shall be situated at convenient locations, clearly marked, and control handles or equivalent shall return automatically to stop position when not being operated.

Guidance note:

For wireless remote control systems, see Sec.4 [3.1.7].

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

5.3.1.3 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 two devices simultaneously.

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

5.3.1.4 Hydraulically operated systems shall be designed to remain safe and stable during all operating conditions, including loss of power and emergency operation.

5.3.1.5 Control stations 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.

5.3.1.6 The person being lifted shall have the possibility to operate and override the same functions as those operated at the remote control position(s).

Guidance note:

This requirement is not applicable to man-riding winches.

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

5.3.1.7 Means of safe return of personnel by override of local control from a remote operating position shall be installed.

5.3.2 Safety functions/systems

5.3.2.1 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.

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

5.3.2.2 Emergency stop shall be implemented according to Sec.5 [7].

5.3.2.3 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 position indicators.

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

5.3.2.4 Provisions for emergency lowering of the lifting device shall be readily available in the event of power failure or other unintended stop, to ensure safe escape from the lifting device. Clear instructions on how to operate equipment during emergency lowering shall be available for operator. 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. Other unintended stop is not meant to cover internal mechanical failures.

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

5.3.2.5 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.

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

5.3.2.6 Both emergency lowering and hoisting shall ensure the safe escape of person(s) lifted within 10 minutes of the start of the emergency.

Guidance note:

The lowering and hoisting speed should not exceed 1.0 m/s.

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

5.3.2.7 Maximum deceleration during emergency braking, shall not harm personnel being transported.

5.4 Man-riding winches - operative functions/systems

5.4.1 Man-riding winch shall be understood as winch with foundation, drum and driving gear, wire rope, sheave arrangement, and personnel lifting tool to be connected to the lifting arrangement.

5.4.2 Arrangement

5.4.2.1 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.

If this is accomplished by means of counterweights, the counterweights shall be arranged to avoid interference or jamming with other components, or potential for personnel injury.

5.4.2.2 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, no damage to wire rope, and that the angle between wire rope and drum or sheave is within ± 4^{o}.

5.4.2.3 Sheave arrangement shall be fitted with protection, ensuring that derailing of wire rope does not occur.

5.4.2.4 The diameter ratio between sheave and wire rope shall be minimum 18:1.

5.4.2.5 Winches used for man-riding equipment shall be designed with fixed operation up and down (i.e. no free fall with brakes).

5.4.2.6 Man-riding winches designed to lift one person in a riding belt shall have a maximum SWL of 150 kg.

5.4.3 Drum and wire

5.4.3.1 Spooling apparatus shall be fitted as necessary to ensure satisfactory spooling of wire rope and to prevent derailing of wire rope.

5.4.3.2 Diameter ratio between drum and wire rope shall be minimum 18:1.

5.4.3.3 Wire ropes shall have a minimum breaking strength of 10 × SWL and shall otherwise be in accordance with a recognised standard applicable to the intended use.

5.4.3.4 Wire rope shall have a diameter of minimum 10 mm.

5.4.3.5 At least 3 turns of wire rope shall remain on the drum at the lowest possible operating position of lifting device.

5.4.4 Brakes

5.4.4.1 The winch shall be equipped with two mechanically and functionally independent braking system; the operative brake and the emergency brake.

The operative brake shall be capable of stopping and holding the load upon activation.

Guidance note:

Hydraulic restriction may be considered as one of the required two brakes.

For emergency brake, see [5.5.1].

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

5.4.4.2 If hydraulic restriction is used as a brake, the following applies:

— Hydraulic motor shall have a closing valve directly at the high pressure (load) connection (no pipe or hose connection in between).
— 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.
— Hydraulic motor shall always be ensured sufficient working fluid, also in the event of power failure, i.e. gravity feeding.

5.4.4.3 Operative brake shall automatically engage upon emergency stop, power loss, or other related energy failure (e.g. hydraulic accumulator, spring, etc.).

5.4.4.4 Operative brake shall be automatically engaged when the control devices are in neutral position.

5.4.4.5 Operative brake shall be capable of holding a static load of 1.8 × SWL.

5.4.4.6 Operative 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.

5.4.4.7 Operative brake 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.

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

5.5 Man-riding winches - safety functions/systems

5.5.1 Emergency brake

5.5.1.1 The brake shall be capable of stopping and holding the load upon activation.

For hydraulic restriction brake, [5.4.4.2] applies.

5.5.1.2 The brake shall automatically engage upon emergency stop, power loss, or other related energy failure (e.g. hydraulic accumulator, spring, etc.).

Guidance note:

During normal operation, the emergency brake may be activated manually.

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

5.5.1.3 The brake shall be capable of holding a static load of 1.8 × SWL.

5.5.1.4 The 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.

5.5.1.5 The brake shall be designed to avoid unintentional release.

5.6 Other man-riding equipment

5.6.1 Operative functions/systems

5.6.1.1 Failure of a roller or wheel on a man-riding platform or trolley shall not endanger the safety of the rider.

5.6.1.2 Stabbing boards, access baskets, etc., shall be provided with control stations, both locally at the platform/basket and at a suitable remote location.

5.6.1.3 Mobile elevating platforms shall be installed on guided tracks.

5.6.2 Safety functions/systems

5.6.2.1 Casing stabbing boards shall be fitted with an additional mechanical locking device that will safely stop and hold the board in the event of system failure.

5.6.2.2 Mobile elevating platforms shall have a mechanical anti-tipping device, to prevent the platform from tipping over under all relevant loading conditions.

6 Other systems

6.1 Introduction

6.1.1 This subsection describes requirements for other systems, including equipment such as, but not limited to:

— winches
— gear transmissions.

6.1.2 The systems shall be capable of preventing, or support the prevention of, relevant hazardous events from occurring. If occurred, the system shall mitigate, or support the mitigation of, the consequences of such an event.

The following hazardous event is considered in this subsection:

— dropped load.

6.1.3 Categorisation for operative barrier functions, and their corresponding safety functions (and systems, where relevant), shall be as provided in Table 7 for the hazardous event listed in [6.1.2].

Table 7 Barrier function categorisation for other systems

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		
Stop and hold load	Important	Stop and hold load (Emergency braking system)	Dropped load
Lower load	Important	Lower load (Emergency lowering)	Dropped load
Maintain structural integrity	Essential	1)	Dropped load

1) With respect to structural integrity, required safety and integrity may be obtained through design, manufacturing and maintenance of the operative barrier.

Guidance note:

For general requirements and description of barriers and functions, see Sec.1.

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

6.2 Winches

6.2.1 Operative functions/systems

6.2.1.1 Winches shall safely hoist, lower, stop and hold the maximum allowable load.

6.2.1.2 This subsection is applicable to all winches within the drilling area, except those used for man-riding purposes (see [5]), but including winches used for integrated purposes.

6.2.1.3 All winches located in normally manned areas shall be shielded for personnel protection and clearly marked with the maximum permissible working load (SWL).

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

6.2.1.5 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.

6.2.1.6 Air-powered winches shall be provided with regulators to prevent loads exceeding SWL.

6.2.1.7 When spooling operation is not directly visible for the operator of the winch, fitting of spooling device should be considered.

6.2.2 Safety functions/systems

6.2.2.1 Emergency stop shall be implemented according to Sec.5 [7].

6.2.2.2 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.

6.2.2.3 Provisions for emergency lowering of the lifting device shall be readily available in the event of power failure or other unintended stop. Clear instructions on how to operate equipment during emergency lowering shall be available for operator. Frictional coupling or clutch shall not be used for emergency operation.

Guidance note:

Other unintended stop is not meant to cover internal mechanical failures.

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

6.2.2.4 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.

6.2.2.5 Brakes shall be designed to be capable of holding a static load of 1.8 × SWL.

6.2.2.6 If brakes relying on mechanical friction are fitted, they shall comply with [2.2.5.2].

6.2.2.7 The system shall be provided with automatic upper and lower hook-stops.

6.3 Gear transmissions

6.3.1 Operative functions/systems

Gears transmitting braking forces 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 operative loads and possible brake loads.

Guidance note:

Gear transmissions for less-important applications, e.g. for non-hoisting purpose, may be accepted without such documented design.

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

SECTION 7 WELL PRESSURE AND FLOW CONTROL SYSTEMS

1 Introduction

1.1 Well barriers

1.1.1 Well pressure and flow control systems are systems providing pressure and flow control in the well.

These systems shall as a minimum provide two well barriers:

— the operative well barrier: an operative barrier allowing normal operation
— the safety well barrier: a safety barrier ensuring well shut-in and disconnect upon loss of the operative barrier.

1.1.2 The operative well barrier is established and maintained through a barrier envelope called well influx prevention (WIP), providing pressure and flow control while allowing normal drilling operations and access in and out of the well.

In case of a detected influx or instability in the WIP barrier, the drilling operation might come to a stop. A second operative well barrier, well influx management (WIM), may then be activated, focusing on re-establishing full pressure and flow control. The WIM barrier facilitates re-establishment of the WIP barrier, and drilling can be resumed.

Guidance note:

The WIP operative well barrier (see [3]) in its normal working stage may constitute a single or a multiple gradient fluid column and/or mechanical devices, while the WIM operative well barrier (see [4]) may constitute drill string valves, annular preventers, pipe rams, and choke and kill equipment.

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

1.1.3 Upon a total loss of both operative barriers (WIP and WIM), a safety barrier (safety system) called wll shut-in and disconnect (WSD) shall be available for activation.

Guidance note:

The WSD safety well barrier (see [4]) in its ultimate stage will normally constitute shear ram(s), choke/kill line valves, riser connector (for floating MODUs) and their respective control system.

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

1.1.4 Well barriers shall as a minimum be designed, constructed and maintained such that they are robust for all expected load combinations.

Well barriers shall:

— withstand the maximum rated differential pressure
— be leak tested and function tested or verified by other methods
— withstand the environment for which it may be exposed to over its life time
— be arranged such that it is safe to replace well barrier elements
— facilitate re-establishment of a lost well barrier, or establishment of other temporary well barrier(s)
— be monitored for physical location and integrity status, at all times.

Guidance note:

The scope of this standard does not cover all barrier elements, e.g. wellhead and well barrier elements located below wellhead are not covered by the scope of this standard.

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

2 Bulk and mixing systems

2.1 Introduction

2.1.1 Bulk and mixing systems shall mix drilling fluid from dry bulk.

2.1.2 This subsection describes requirements for bulk and mixing systems, including equipment such as, but not limited to:

— pressurized storage tanks (e.g. cement, barite, bentonite) and associated piping and valves
— bulk transfer system, including pumps
— safety valves
— mud mixing facilities
— control and monitoring.

2.1.3 Bulk and mixing systems shall be capable of preventing, or support the prevention of, relevant hazardous events from occurring.

Accidental release of pressurized fluids is considered in this subsection.

2.1.4 Categorisation for accidental release of pressurized fluids is provided in Sec.5 [2].

2.2 Operative functions/systems

2.2.1 Performance of the mud mixing facilities (inclusive passive mud tanks) shall be adequate for the intended drilling program (e.g. system capacity).

2.2.2 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.

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

2.3 Safety functions/systems

2.3.1 All bulk storage tanks shall be equipped with safety valves or rupture discs to prevent damage due to overpressure.

Guidance note:

Rupture discs may only be used for bulk storage tanks in open areas, or if fitted with a relief line to an open area.

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

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

2.3.3 Means to avoid clogging of bulk material in safety valve relief line shall be implemented.

Guidance note:

This may be obtained by a downward slope of the line or installation of purging possibilities.

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

3 Well influx prevention - drilling fluid circulation and cementing systems

3.1 Introduction

3.1.1 Well influx prevention systems shall provide drilling fluid circulation/cementing (including transfer), while preventing well influx and allowing for drilling operations to be performed.

3.1.2 This subsection describes requirements for WIP systems, covering equipment such as, but not limited to:

— high pressure mud and cement pumps
— pulsation dampeners
— discharge manifolds, piping, hoses and valves
— feed and transfer pumps
— mud treatment system
— trip tanks and active pits
— control and monitoring system
— managed pressure drilling (MPD) systems (where installed, see [3.1.3]).

3.1.3 Where MPD systems are installed, additional requirements are provided in this section, covering equipment such as, but not limited to:

— flowspool/MPD riser joints
— riser isolation tool
— rotating control device (RCD)
— manifolds, piping, hoses and valves
— pressure relief valves
— dedicated solids treatment equipment
— dedicated mud-gas separator (MGS)
— dedicated pumps
— flow meters
— power supply
— control and monitoring system.

3.1.4 Drilling fluid circulation and cementing systems shall be capable of preventing, or support the prevention of, relevant hazardous events from occurring. If occurred, the system shall mitigate, or support the mitigation of, the consequences of such an event.

The following hazardous events are considered in this subsection:

— blowout
— blowout (without BOP installed)
— riser gas release.

3.1.5 Categorisation for operative barrier functions, and their corresponding safety functions (and systems, where relevant), shall be as provided in Table 1 and Table 2 (additional functions for MPD systems), for the hazardous events in [3.1.4].

Table 1 Barrier function categorisation for drilling fluid circulation and cementing systems

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		
Provide availability of drilling fluid with correct properties	Important	Shut in well (WSD system)	Blowout
		Divert well fluids overboard (Diverter system)	Blowout (without BOP installed)
			Riser gas release
Pump sufficient drilling fluid with correct parameters into well	Important	Shut in well (WSD system)	Blowout
		Divert well fluids overboard (Diverter system)	Blowout (without BOP installed)
			Riser gas release
Recondition mud returns (including separation and venting)	Important	Shut in well (WSD system)	Blowout
		Divert well fluids overboard (Diverter system)	Blowout (without BOP installed)
			Riser gas release
Monitoring of relevant parameters (pressure, flow in/out, drilling fluid properties in/out, etc.)	Important	Shut in well (WSD system)	Blowout
		Divert well fluids overboard (Diverter system)	Blowout (without BOP installed)
			Riser gas release
Pressure containment - Maintain structural integrity	Important	Shut in well (WSD system)	Blowout
		Divert well fluids overboard (Diverter system)	Blowout (without BOP installed)
			Riser gas release

Guidance note:

For WSD systems, see [4].

For diverter systems, see [5].

For general hazards (e.g. accidental release of pressurized fluids), see Sec.5 [2].

For general requirements and descriptions of barriers, functions and systems, see Sec.1.

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

Table 2 Barrier function categorisation for MPD systems

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		
Maintain desired bottomhole pressure by adjusting back-pressure (pressurizing annulus and controlling pressure/flow within specified limits)	Important	Shut in well (WSD system)	Blowout
		Divert well fluids overboard (Diverter system)	Riser gas release

Maintain desired bottomhole pressure by adjusting fluid column parameters (pumping and controlling fluid column level/ pressure)	Important	Shut in well (WSD system)	Blowout
		Divert well fluids overboard (Diverter system)	Riser gas release
Safely process and vent returned gas	Important	Shut in well (WSD system)	Blowout
Monitoring of relevant parameters (pressure, flow in/out, drilling fluid properties in/out, etc.)	Important	Shut in well (WSD system)	Blowout
Pressure containment - Maintain structural integrity	Important	Shut in well (WSD system)	Blowout

3.2 Operative functions/systems

3.2.1 Drilling fluid tank volume shall, in all operational modes, be sufficient for the intended well volume.

Sufficient volume may be ensured by automatic or manual transfer, but if the transfer is automatic, "high level" alarm shall be provided.

Guidance note:

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

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

3.2.2 Where required, see Sec.4 [2.1.3], the drilling fluid and cementing system shall be arranged for emergency circulation.

Guidance note:

This may be arranged by using cement pump, see [3.2.3], and other necessary systems/equipment required (both supply and return).

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

3.2.3 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 connected to emergency power, or dedicated emergency transfer pumps (with e.g. emergency power supply) which transfer drilling fluid from the mud pits to the cement pump.

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

3.2.4 Degasser shall be vented to a safe location.

3.2.5 High pressure mud pumps shall be fitted with pulsation dampeners.

3.2.6 Control and monitoring

3.2.6.1 Necessary control and condition monitoring of the system shall be provided and be available at the control station(s) in order to detect abnormal conditions that might lead to loss of essential or important functions, and take necessary actions.

The following shall, unless otherwise agreed, be monitored (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 to the well and returned to the MODU/OI. The indicator should be capable of compensating for rig movements
- gas content in the mud.

3.2.6.2 Alarm shall be initiated for abnormal conditions.

Guidance note:

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

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

3.2.7 Managed pressure drilling systems - general

3.2.7.1 MPD systems shall be designed such that the pressures in the mud flow loop will not exceed the predefined operational pressure limitations.

3.2.7.2 An MPD system shall be qualified for all operations for which it will be deployed.

3.2.7.3 Debris sizes and extent shall be considered when selecting internal dimension of MPD piping (including manifolds), in order to prevent plugging.

Guidance note:

Where needed, additional filtration of debris should be considered (e.g. junk catcher).

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

3.2.7.4 Flow and erosion analyses shall be performed for the MPD system.

The analyses shall cover the flow and erosion ranges that the system might be exposed to, and as a minimum cover a defined normal conditions scenario and a worst case scenario.

3.2.7.5 Two isolation valves in series shall be installed to isolate all lines between the MPD system and the following systems:

- Choke and kill system (including mud/gas-separator, choke and kill manifold, etc.)
- High pressure systems (including standpipe manifolds, mud and cement manifolds, etc.).

3.2.7.6 MPD systems (operative system) shall not have connections to the well shut-in and disconnect system (safety system), (see [4.1.4]).

3.2.7.7 A minimum of two drill string valves or non-return valves shall be used to account for pressure imbalance between drill string and annulus.

3.2.7.8 If a flowspool is installed as part of the marine drilling riser string, two isolation valves in series shall be installed directly on the flowspool outlets.

Guidance note:

For flowspools and other MPD riser components, see also [7].

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

3.2.7.9 If flow can be routed to multiple flow paths, interlock shall be installed, in order to always ensure open flow path.

3.2.7.10 Provisions for hydrate prevention shall be installed where relevant.

3.2.7.11 Operational parameters for essential/important and safety functions shall be displayed to MPD operator. Where driller is not MPD operator, operational parameters for MPD safety functions shall be displayed to driller.

3.2.8 Managed pressure drilling back-pressure systems - choke manifolds

3.2.8.1 MPD choke manifolds shall as a minimum include two chokes.

Guidance note:

Two isolation valves in series should be installed where necessary, see Sec.5 [3.1.5].

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

3.2.8.2 One choke (or a bypass line) shall be readily available (not used in normal operation) for manifolds connected to a mud/gas-separator.

3.2.8.3 As a minimum, choke position, pressure and temperature indications upstream of the chokes shall be provided to relevant control station(s).

Indications shall also be provided locally where manually operated chokes are installed.

3.2.9 Managed pressure drilling back-pressure systems - rotating control device

3.2.9.1 Rotating control device (RCD) shall have at least two packing elements.

Guidance note:

RCDs should be equipped with ability to monitor pressure between packing elements, and to monitor the bearing condition.

The two packing elements should be spaced such that a standard drill pipe tool joint cannot occupy both packing elements at the same time.

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

3.2.9.2 RCDs shall have provisions for venting of gas trapped between the packing elements and below the lower packing element.

3.2.9.3 It shall be possible to change out packing elements without retrieving the RCD.

3.2.9.4 RCDs shall be designed with fail-safe locking/latching mechanism to prevent accidental unlocking.

3.2.9.5 RCDs shall be able to hold specified pressure at specified operational conditions (e.g. temperature range, etc.), against specified maximum and minimum drill pipe sizes.

3.2.9.6 RCDs shall undergo design validation/verification testing for specified pressure, temperature, RPM and fluid compatibility.

Guidance note:

RCDs should be tested to document effects of side loading on sealing performance and life expectancy of packing elements.

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

3.2.10 Managed pressure drilling back-pressure systems - subsea blowout preventer

3.2.10.1 A riser isolation tool shall be installed below the RCD.

3.2.10.2 Pressure between RCD and riser isolation tool shall be measured and it shall be possible to equalize/ bleed off trapped pressure between the devices.

3.2.10.3 When the RCD is installed as part of the drilling riser string, two isolation valves in series shall be installed directly on the RCD bleed off lines.

3.2.11 Managed pressure drilling multiple-gradient systems - subsea blowout preventer

As a minimum, three independent pressure transmitters shall be provided for riser fluid level indications. Deviation between indicating devices shall result in alarm to manned control station.

3.3 Safety functions/systems

3.3.1 High pressure pumps shall be fitted with safety relief valves set at or below the maximum allowable pressure of the system.

3.3.2 Relief lines from safety valves shall be self-draining.

3.3.3 Emergency stops shall be implemented on high pressure pumps in accordance with Sec.5 [7].

3.3.4 Managed pressure drilling systems - general

3.3.4.1 If valves for overboard relief lines are installed as part of the MPD system, or integrated with the MPD system, an interlock shall be provided, always ensuring an open flow path.

3.3.4.2 Gas detectors shall be installed in upper part of riser (e.g. bell nipple/diverter housing).

3.3.5 Managed pressure drilling back-pressure systems

For MPD systems applying controlled back-pressure, an independent system preventing over-pressurization of riser and MPD system shall be installed.

Status for the system shall be displayed on all MPD control stations.

Guidance note:

The relief system may be provided by mechanical components and/or by a computer-based safety system which is independent of the MPD control system.

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

4 Well influx management and well shut-in and disconnect

4.1 Introduction

4.1.1 Well influx management systems (WIM) shall manage a well influx while allowing for circulation. Well shut-in and disconnect system (WSD) shall shut in the well and disconnect.

4.1.2 This subsection describes requirements for WIM and WSD, including equipment such as, but not limited to:

— annular preventers
— shear and seal ram preventers
— pipe ram preventers
— choke/kill line valves
— wellhead connector
— riser connector (for floating MODUs)
— valves in drill string
— control and monitoring system(s).

Guidance note:

WIM is considered an operative system and may contain BOP equipment frequently used in drilling operations, allowing such equipment to be integrated with/controlled through other operative control systems (e.g. drilling control system). This might improve both operability and safety by facilitating efficient integration of new drilling techniques and automated processes (e.g. automatic space out and hang-off, dynamic well control, etc.).

BOP equipment controlled through an operative control system (WIM) will require the equipment, its control, monitoring and utilities to be independent from safety systems, (see [4.1.4] for WSD).

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

4.1.3 Well shut-in and disconnect system (WSD) shall provide the functionality of the safety well barrier.

Minimum required safety functionality (WSD) is:

— shear tubulars in wellbore
— shut in well
— disconnect riser (as applicable).

4.1.4 The WSD system is a safety system and shall comply with requirements for safety systems.

The WSD system shall as a minimum contain the following equipment:

— shear and seal ram preventers
— choke/kill line valves
— wellhead connector
— riser connector (for floating MODUs)
— control and monitoring system (WSD control system).

The WSD system may also contain other equipment listed in [4.1.2].

If other equipment (e.g. annular preventers, pipe ram preventers, connectors, etc.) is included in the WSD system, the equipment (including its control, monitoring and utilities) will be part of a safety system and shall comply with requirements for safety systems (e.g. as a conventional BOP system arrangement).

Guidance note:

An overview of BOP control system alternatives is provided in Table 3:

Table 3 BOP control system configuration alternatives

BOP control system configuration	*WIM system categorisation (controlled by)*	*WSD system categorisation (controlled by)*
Split	Operative (WIM control system and/or other operative control system)	Safety (WSD control system)
Combined (conventional arrangement)	N/A	Safety (BOP control system)

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

4.1.5 WIM and WSD systems shall be capable of preventing a blowout from occurring.

4.1.6 Categorisation for operative barrier functions (WIM), and their corresponding safety functions (WSD), is provided in Table 4 for the hazardous event in [4.1.5].

Table 4 Barrier function categorisation for well influx management

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		
Sealing wellbore by closing around tubular	Important	Shut in well (WSD system)	Blowout
Sealing wellbore by closing on open hole	Important	Shut in well (WSD system)	Blowout
Closing inside of tubular	Important	Shut in well (WSD system)	Blowout
Allow for drill string hang off	Important	Shut in well (WSD system)	Blowout
Allow for stripping operations	Important	Shut in well (WSD system)	Blowout
Pressure containment - maintain structural integrity	Essential	1)	Blowout

1) With respect to structural integrity, required safety and integrity may be obtained through design, manufacturing and maintenance of the operative barrier.

Guidance note:

For general hazards (e.g. accidental release of pressurized fluids), see Sec.5 [2].

For general requirements and description of barriers and functions, see Sec.1.

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

4.2 General (well influx management/well shut-in and disconnect)

4.2.1 The blowout preventer stack shall as a minimum be designed to shut in well and withstand the maximum differential pressure and other relevant loads it will be exposed to in operation.

Guidance note:

Annular preventers may have lower pressure rating than the ram preventers.

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

4.2.2 The blowout preventer stack shall be designed to enable fluids with cuttings to flow out of the system, and to enable fluid to be pumped into the system.

4.2.3 When pumping or flowing through choke or kill lines, due consideration shall be given to possible erosion. Pumping and flowing shall not take place at rates that might cause excessive erosion and lead to impairment of BOP choke and kill line outlets and choke/kill line valves.

4.2.4 Blind shear rams, blind rams and pipe rams shall be equipped with mechanical locking devices.

4.2.5 Pipe rams shall be designed for any hang-off loads to which they may be subjected.

4.2.6 Control stations - general

4.2.6.1 Control stations shall be provided with capability to:

- control the BOP functions
- control the diverter functions (if installed)
- control the pressure regulation of functions that require variable control pressure (as applicable)
- monitor system pressures (as applicable)
- monitor status of all BOP preventers/C&K line valves/connectors (i.e. open or closed/locked)

  Guidance note:

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

  ---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
- monitor status of all alarms (as applicable).

4.2.6.2 When the control system or a control station is reset, no functions shall automatically activate / change position due to the reset.

Guidance note:

E.g. regulators should not lose their set point, closed rams/valves to remain closed, etc.

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

4.2.7 Control stations - arrangement

Control systems shall as a minimum be provided with means for control of the system from two locations, where:

- One control station shall be installed on the drill floor to provide accessibility for the drill crew (driller).
- One control station shall be installed in an area safe by location (away from the drill floor, e.g. toolpushers office).

4.2.8 Availability of control

All control stations shall be available for control when the BOP is deployed.

System for transfer of control between control stations is not accepted.

4.2.9 Alarm system

4.2.9.1 Alarms shall be shown on a panel or screen that is continuously available for an operator.

4.2.9.2 Presentation of alarms shall not block or hide control or presentation of BOP control functions.

4.2.9.3 Alarms and indicators not required for operation or the safety of the control system, shall not be presented on the control stations.

Guidance note:

Such alarms and indicators may e.g. be presented on maintenance stations.

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

4.2.9.4 Deviations between a command and expected result of the command action shall initiate an alarm. Alarms shall be generated from the instrument or system component that is closest to the actuating device.

4.3 Operative functions/systems (well influx management) - general

4.3.1 Stored energy

4.3.1.1 Accumulators for surface and subsea stacks shall as a minimum meet the capacity requirements (volume and pressure) of API Spec 16D.

4.3.1.2 Stored energy provided by other means than accumulators shall provide same functional capacity and comply with all applicable requirements.

4.4 Safety functions/systems (well shut-in and disconnect) - general

4.4.1 WSD systems shall be capable of well shut-in by shearing and sealing under defined worst-case conditions, and to disconnect from well (as applicable).

4.4.2 WSD systems shall be arranged for both automatic activation (e.g. by Deadman, Autoshear, riser angle initiated activation, etc.) and manual activation (e.g. by EDS, WSD control station, etc.).

4.4.3 WSD systems shall be independent of operative systems.

4.4.4 Transfer of data from WSD control system to an operative system for monitoring purposes may be accepted, provided data is in “read only” format and no data or commands shall be transferred to the WSD control system.

4.4.5 Activation devices for riser disconnection (as applicable) and shear rams shall have additional protection against inadvertent operation.

Guidance note:

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

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

4.4.6 Stored energy

4.4.6.1 The WSD system shall have dedicated stored energy to perform the WSD functions.

4.4.6.2 Accumulators for surface and subsea stacks shall as a minimum meet the accumulator capacity requirements (volume and pressure) of API Spec 16D, with the following additional requirements:

— where reference is made to EDS for accumulator capacity, accumulator capacity calculations shall include shearing with largest operating volume shear ram (e.g. CSR), and subsequent sealing[1)] with largest operating volume blind shear ram
— calculations shall use shearing of the thickest section of the heaviest drill pipe (e.g. CSR), casing which will be run across hydrocarbon bearing zone (CSR), wire/cable or landing string shear sub specified for use, and subsequently seal the wellbore (BSR)
— shearing/sealing pressures shall be compensated for wellbore pressure (normally annular preventer design pressure), unless test results are obtained by shearing/sealing against full wellbore pressure
— pressure required for both shearing and sealing shall be used (whichever is higher).

1) Unless functionality is available, in all operational scenarios, to facilitate blind shear ram closing on open hole, shearing with largest operating volume blind shear ram shall also be included in the accumulator capacity calculations.

4.4.6.3 Where annular preventer(s) and pipe ram(s) are included in the WSD system (e.g. as a conventional BOP system, see Table 3), the following shall also apply in addition to [4.4.6.2]:

— where reference is made to the drawdown test in API Standard 53, the four largest operating volume ram-type BOPs shall be used in the calculations, not the four smallest.

4.4.6.4 Stored energy provided by other means than accumulators shall provide same functional capacity and comply with all applicable requirements.

4.4.7 Back-up means of operation

Where the normal user interface for the control system is screen-based, a back-up means of operation/user interface is required.

The back-up means of operation shall be independent of the normal user interface and its communication networks.

Back-up means of operation shall as a minimum be available for the functions provided in [4.1.3].

Activation signals shall be hardwired individually and directly to the respective controller.

Guidance note:

Back-up means of operation should be based on proven and reliable design, and be located adjacent to the normal operating station.

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

4.5 Surface blowout preventers

4.5.1 A blowout preventer (BOP) surface stack shall as a minimum consist of the following:

— one annular preventer
— one blind shear ram
— two pipe rams
— choke/kill line valves
— wellhead connector
— necessary control and monitoring equipment.

Guidance note:

The above configuration is also valid for surface stacks that might be installed subsea, e.g. from jack-ups. Applicable additional requirements shall be identified through risk assessments.

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

4.5.2 General (well influx management/well shut-in and disconnect)

4.5.2.1 Operation of surface systems shall be provided from minimum two control stations.

For surface systems where operation may be performed on the hydraulic manifold, the hydraulic manifold shall not be considered one of the two required control stations.

4.5.2.2 The hydraulic manifold of the control system, including pilot valves, shall be placed in a protected area in order to avoid exposure in the event of an uncontrolled well situation.

4.5.2.3 For systems with topside pods, pods shall be designed and constructed for accidental loads as specified in Sec.5 [5.4] and DNVGL-OS-A101 Ch.2.

4.5.2.4 BOP systems, where the BOP stack can be installed both surface and subsea, shall be provided with the following when installed subsea:

— two independent pods
— two independent hoses/umbilicals.

4.5.2.5 Control lines (including any component of the control lines) shall be capable of withstanding a fire for sufficient time for necessary operation of the preventers.

Guidance note:

See API Spec 16D.

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

4.5.3 Safety functions/systems (well influx management)

4.5.3.1 At least one shear ram shall be installed, capable of shearing the thickest section of the heaviest drill pipe, casing (which will be run across hydrocarbon bearing zone), slack wire/cable or landing string shear sub specified for use.

Shearing capabilities shall be specified and documented.

4.5.3.2 If tool joints cannot be sheared, either

— two shear rams must be installed (at least one blind shear ram) and spaced such that one tool joint cannot occupy both shear ram cavities at the same time (i.e. spacing between shear rams must be more than the length of the longest tool joint to be used), or
— lifting or lowering with drilling hoisting system, to be able to shear work string, shall be possible in all operational modes, including emergency operation.

4.5.3.3 Two valves shall as a minimum be installed in series close to the stack for each of the choke and kill lines.

These choke/kill line valves shall be located so that they are protected against damage from falling objects. The valves shall be capable of operation under worst predictable conditions (e.g. specified flow, pressure, temperature, etc.).

The valves shall be according to one of the following:

— two remotely controlled valves, both shall be of the fail-to-close type
— one remotely controlled valve and one manually operated.

Where manually operated valves are installed, safe access for operation shall be available when BOP is installed on wellhead/riser.

4.5.3.4 WSD control system shall comply with requirements for R0 restoration time, see Sec.1 [3.2.3]. Alternatively, the following conditions shall be complied with:

— operation can be performed on the hydraulic manifold
— hydraulic manifold is easily accessible from drill floor, and from alternative access route avoiding drill floor and cellar deck/BOP deck (also accessible during hazardous events)
— control panels are directly connected to the ECCU or by ring structure
— the ECCU is located in protected area.

4.6 Subsea blowout preventers

4.6.1 A blowout preventer (BOP) subsea stack shall as a minimum consist of the following:

— one bag-type annular preventer
— two shear rams, where at least one is a blind shear ram
— two pipe rams
— choke/kill line valves
— wellhead connector
— riser connector (for floating MODUs/OIs)
— necessary control and monitoring equipment.

Guidance note:

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

For anchored MODUs/OIs, one blind shear ram might be accepted based on a risk assessment proving it fit for purpose. See also Sec.4 [2.1.3].

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

4.6.2 General (well influx management/well shut-in and disconnect)

4.6.2.1 Design of the stack assembly (including LMRP and connectors) shall take into account relevant loads induced by the BOP handling. Maximum operational, survival, transit, and accidental heel design conditions shall be specified in accordance with Sec.5 [5]. Loads from securing arrangements shall be taken into account.

Guidance note:

Design calculations should be evaluated in accordance with Sec.5 [6]. Due consideration should be given to the effects of wave slamming and sea current forces as the stack is deployed.

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

4.6.2.2 Assembled subsea stack drill through column and the individual drill through components (including riser connector) shall include evaluation of external load limits combined with maximum operating pressure. Combinations of loads for drilling and non-drilling conditions with the riser connected should be considered in the evaluations.

Guidance note:

Subsea stack assembly external load limits may be specified as equivalent tension at maximum operating pressure, see API Spec 16F. Such limits are to be considered together with the global riser analysis, which should also include, among others; soil stiffness and the characteristic of conductor/wellhead, BOP, ball/flexible joint and riser tension system.

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

4.6.3 Safety functions/systems (well shut-in and disconnect)

4.6.3.1 At least one shear ram shall be capable of shearing the thickest section of the heaviest drill pipe, casing (which will be run across hydrocarbon bearing zone), slack wire/cable or landing string shear sub specified for use.

Shearing capabilities shall be specified and documented.

4.6.3.2 Two shear rams shall be spaced such that one tool joint cannot occupy both shear ram cavities at the same time (i.e. spacing between shear rams must be more than the length of the longest tool joint to be used).

4.6.3.3 Two valves shall as a minimum be installed in series close to the stack for each of the choke and kill lines (choke/kill line valves).

The valves shall be located so that they are protected against damage from falling objects. The valves shall be capable of operation under worst predictable conditions (e.g. specified flow, pressure, temperature, etc.).

The valves shall be provided with remote control and shall be of the fail-to-close type.

4.6.3.4 Hydraulically operated wellhead and riser (LMRP) connectors shall have redundant mechanisms for unlock and disconnect. The secondary unlock mechanism shall operate independently of the primary unlocking mechanism.

4.6.3.5 Unlatching of the wellhead connector shall be protected with a key lock, protective cover or interlock within the control system. The protection method shall be different from the protection method used for the riser connector unlatch function (as applicable).

4.6.3.6 The maximum flex joint angle and riser tension combination allowing riser connector emergency disconnect shall be specified.

Guidance note:

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

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

4.6.3.7 For dynamically positioned MODUs, the driller shall always be informed of the MODUs position in relation to wellhead.

Guidance note:

The position can be provided as a traffic light indication from DP system.

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

4.6.3.8 Special considerations shall be given to MODUs 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---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.6.4 Discrete hydraulic systems (well influx management/well shut-in and disconnect)

4.6.4.1 Operation shall be provided from minimum two control stations.

For surface systems where operation may be performed on the hydraulic manifold, the hydraulic manifold shall not be considered one of the two required control stations.

4.6.4.2 Two independent pods shall be provided for all hydraulic lines from the hydraulic manifold.

4.6.5 Discrete hydraulic systems (well shut-in and disconnect)

WSD control system shall comply with requirements for R0 restoration time, see Sec.1 [3.2.3].

Alternatively, the following conditions shall be complied with:

— operation can be performed on the hydraulic manifold
— hydraulic manifold is easily accessible from drill floor, and from alternative access route avoiding drill floor and cellar deck/BOP deck
— control panels are directly connected to the ECCU or by ring structure
— the ECCU is located in protected area.

4.6.6 Multiplex systems (well influx management/well shut-in and disconnect)

Operation shall be provided from minimum two control stations.

4.6.7 Multiplex systems (well shut-in and disconnect)

WSD control system shall comply with requirements for R0 restoration time, see Sec.1 [3.2.3].

ECCUs shall be located in area safe by location.

4.6.8 Secondary control system (well influx management/well shut-in and disconnect)

4.6.8.1 Subsea stacks shall have ROV intervention capabilities installed as a secondary control system in the event of failure of main control system.

Secondary control systems shall be independent of the main control system.

Guidance note:

An acoustic control system may be installed as an optional secondary control system.

For further requirements to secondary control systems, see API Standard 53 and API Spec 16D.

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

4.6.8.2 Secondary control systems shall meet the accumulator capacity requirements (volume and pressure) of API Spec 16D.

Guidance note:

For ROV intervention, hydraulic fluid may be supplied by the ROV, stack mounted accumulators (which may be a shared system), or an external hydraulic power source, see API Standard 53.

For accumulator requirements to shared systems, see API Standard 53.

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

4.6.9 Emergency functions (well shut-in and disconnect)

4.6.9.1 The WSD system shall provide:

— well shut-in initiated by automatic activation of e.g. Autoshear, Deadman
— well shut-in and disconnect initiated by manual activation of EDS.

4.6.9.2 Emergency functions, being part of a safety system (WSD), shall comply with requirements for restoration time R0, in accordance with Sec.1 [3.2.3].

4.6.9.3 Subsea stacks shall have Autoshear and Deadman systems installed.

Guidance note:

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

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

4.6.9.4 Subsea stacks on dynamically positioned MODUs shall have provisions for emergency disconnect sequence (EDS).

Guidance note:

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

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

4.6.9.5 If disconnect signal is routed directly from DP system to WSD control system, the interconnection and the signal shall be qualified and of fail-safe design.

It shall be possible to inhibit the signal for disconnect in the WSD control system. When inhibited, this shall be clearly shown on WSD control stations.

Guidance note:

See FMEA requirement in Sec.1 [3.4.1.18].

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

4.6.9.6 Activation of EDS shall initiate and complete well shut-in, including at least one casing shear ram and one blind shear ram, and disconnection in the correct sequence.

Activation of EDS shall not require any additional actions before activation.

Guidance note:

The sequence will depend on stack configuration and operational mode. A typical EDS will be:

— shear tubular/workstring (casing/super shear ram)
— disconnect (riser connector)
— close well (delayed activation of blind shear ram to facilitate sealing on open hole).

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

4.6.9.7 Design of EDS and EDS activation shall take into account required total time for disconnection.

Guidance note:

This will typically depend on:

— maximum LMRP riser angle and riser tension combination for successful mechanical disconnection
— length of telescopic joint/tensioner stroke
— emergency disconnect total time (including unsuccessful shearing, if applicable).

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

4.6.9.8 The following shall as a minimum be taken into consideration for the design of EDS sequences through application of hazard identification (HAZID), hazard operability (HAZOP) and FMEA techniques:

— Possible tool joint in BSR cavity, necessity of lifting sheared tubular from BSR cavity and delay in closing of BSR.
— Influence of drill string heave compensation (active/passive) on sequence (e.g. on lifting of sheared tubular).
— Influence of activated Autodriller on sequence (e.g. on lifting of sheared tubular).
— Rig heave with pipe supported in rotary.

4.7 Valves in drill string (well influx management)

4.7.1 Requirements in this subsection 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.

4.7.2 The drill stem shall be provided with at least two valves located directly below the top drive with sufficient pressure rating, of which at least one shall be remotely operated.

4.7.3 A manual valve in open position for the drill string shall be available for immediate use at all times. The valve shall be of correct 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.

4.7.4 When surface BOPs are installed, the manual valve (see [4.7.3]) shall be of such a design that it can be run through the stack.

4.7.5 If a wrench or other tools are required to close a manually operated valve, such tools shall be kept in a readily accessible place.

4.7.6 Crossovers and similar which is forming part of a barrier against back flow shall also have sufficient pressure rating.

Guidance note:

E.g. used when running casing or other types of pipe.

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

4.8 Test systems

4.8.1 System independence

Where a dedicated system for testing the BOP is provided, the test system shall be totally independent of WSD control system/WIM control system.

Guidance note:

Independence includes electric power, hydraulic power and all other system that is a part of the WSD control system/WIM control system. The requirement does not include utilities supplied from MODU/OI.

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

4.8.2 System installation

Special attention shall be given to testing in hazardous area.

Guidance note:

Additional gas detectors to cover test area should be considered together with isolation of electrical signals to BOP when gas is detected on MODU/OI.

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

5 Well influx relief - diverter systems

5.1 Introduction

5.1.1 Well influx relief systems shall divert well influx, while allowing for drilling fluid circulation in normal operation.

5.1.2 This subsection describes requirements for diverter systems, including equipment such as, but not limited to:

— diverter assembly
— riser gas handling equipment
— related lines and valves
— control and monitoring.

5.1.3 Diverter systems are safety systems providing the safety barrier towards relevant hazardous events.

The following hazardous events are considered in this subsection:

— blowout (without BOP installed)
— riser gas release.

5.1.4 The safety functions provided by the diverter systems are:

— Close annulus and divert well fluids overboard.

Guidance note 1:

For general requirements and description of barriers and functions, see Sec.1.

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

Guidance note 2:

Some safety functions provided by diverter systems are supported by drilling operative systems, e.g. the drilling riser system through integrity of riser main tube, activation of slip-joint packer, etc. (as relevant).

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

5.2 Safety functions/systems

5.2.1 Diverter systems shall be able to safely divert flow away from the MODU/OI after a riser influx.

5.2.2 Diverter systems shall have a suitable pressure and flow rating, reflecting the worst case conditions it might be exposed to.

5.2.3 Diverter systems shall maintain its structural integrity over a time sufficient to safely evacuate the rig.

Guidance note:

Typically 30-45 minutes (minimum).

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

5.2.4 Diverter piping shall have sufficient length to ensure that gas and wellbore fluids are lead away from the MODU/OI. 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.

Two diverter pipe outlets, leading to opposite sides of the MODU/OI shall be installed.

Guidance note:

See API RP 64 for further guidance.

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

5.2.5 Design of diverter systems shall be evaluated for possible erosion during operation, based on analysis or equivalent.

Assumptions for the design of the diverter system shall be stated in the operation manual.

Guidance note:

The evaluation should cover the flow and erosion ranges that the system can be exposed to, and include worst case scenario(s). 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---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.2.6 Flow line directly from the diverter system to the mud/gas-separator is not allowed.

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

5.2.8 Boundary conditions and criteria for riser gas handling application shall be specified. Gas in the drilling riser shall be prevented as far as possible using available drilling equipment (e.g. monitoring equipment).

Guidance note:

Riser gas handling is mainly used to control the pressure in the riser and divert flow from the riser to a safe location, e.g. an MGS or overboard.

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

5.2.9 Dynamic flow and erosion effects due to gas influx into marine drilling riser shall be evaluated for deep water drilling systems applying a riser gas-handling system with a riser isolation tool (e.g. annular type) below the conventional diverter.

Guidance note:

Analysis should cover the flow and erosion ranges that the system can be exposed to, and as a minimum include a worst case influx scenario where the influx is to be circulated through the riser system and to a safe location.

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

5.2.10 Control and monitoring

5.2.10.1 Control stations shall be provided with capability to:

- control the diverter functions
- control the pressure regulation of functions that require variable control pressure (e.g. diverter packer)
- monitor all system pressures
- monitor status of all diverter functions (i.e. open or closed/locked)
- monitor status of all alarms (visual and audible) for at least:
  - low accumulator pressure
  - loss of power supply
  - low levels in control fluid storage tanks.

5.2.10.2 The diverter system shall at least be connected to a control station which is manually operable from a place near the drilling control station (driller's cabin).

Guidance note:

If the diverter control system is combined with the WSD system, see relevant requirements in [4].

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

5.2.10.3 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.

5.2.10.4 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".

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5.2.10.5 Accumulator capacity shall as a minimum comply with API Spec 16D or equivalent.

6 Well normalising - choke and kill systems

6.1 Introduction

6.1.1 After activation of the Well influx management and/or the well shut-in system, the well normalising system shall re-establish the operative well barrier.

6.1.2 This subsection describes requirements for well normalising systems, including equipment such as, but not limited to:

— choke and kill manifold, including components
— choke and kill lines, including components
— choke and kill hoses
— mud/gas-separator
— control and monitoring.

Guidance note:

Requirements to systems/equipment providing pumping functionality are provided in [3].

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6.1.3 The well normalising system is a system used to re-establish full functionality of the operative well barrier (i.e. after activation of the WIM or the WSD system).

6.1.4 Categorisation for operative barrier functions, and their corresponding safety functions (and systems, where relevant), shall be as provided in Table 5 based on their role as a barrier element.

Table 5 Function categorisation for choke and kill systems

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		

Allow for controlled release of fluids trapped below closed BOP	Important	Shut in well (WSD system)	Blowout
Allow for processing, separation and venting of gas from returned fluids	Important	Shut in well (WSD system)	Blowout
Allow for pumping fluids into well when BOP is closed	Important	Shut in well (WSD system)	Blowout
Pressure containment - Maintain structural integrity	Important	Shut in well (WSD system)	Blowout

Guidance note:

For WSD systems, see [4].

For general hazards (e.g. accidental release of pressurized fluids), see Sec.5 [2].

For general requirements and description of barriers and functions, see Sec.1.

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6.2 Operative functions/systems

6.2.1 It shall be possible to pump fluids through the kill and choke manifold and to the BOP stack, up to the rated shut-in pressure of the BOP stack (WSD system).

6.2.2 It shall be possible to route returns from the BOP stack through the choke and kill manifold and to a mud/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 MODU/OI. Alternative arrangements might be accepted after documenting an acceptable safety level.

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6.2.3 Choke and kill lines shall be provided from the BOP stack to the choke and kill manifold.

The lines (including fittings, valves, etc.), and the high pressure side of the manifold, shall be rated to at least the same pressure as the rated pressure of the BOP stack (WSD system).

6.2.4 The choke and kill manifold shall as a minimum include three chokes, of which at least one shall allow for remote control, and at least one for manual adjustment. For manifolds rated at 690 bars (10000 psi) or greater, at least two chokes shall allow for remote control.

Guidance note:

If a remote controlled choke has built-in manual adjustment and is easily accessible, such choke may be considered to satisfy the requirement for choke with manual adjustment.

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6.2.5 Manifold outlet and inlet lines shall have at least one isolation valve installed, such that lines to and from the manifold can be isolated.

6.2.6 Where the pressure rating changes in the manifold (spec. break), two isolation valves rated to the higher pressure shall be installed in series.

6.2.7 For manifolds rated at 345 bars (5000 psi) or higher pressures, two valves in series shall be installed upstream of each of the chokes.

6.2.8 The choke and kill manifold and choke and kill lines shall be arranged such that if a choke fails, immediate rerouting of flow through another choke is possible without interrupting flow control, for all relevant operational scenarios (including pumping through one line whilst there is simultaneous flow return through the opposite line).

Guidance note:

When pumping through one line whilst there is simultaneous return flow through the opposite line, two isolation valves should be considered installed in the manifold where leakage between the kill and choke lines might prevent correct flow indications in and out of well.

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6.2.9 The choke and kill manifold shall be configured such that the choke line and the kill line from/to the BOP, both can provide the choke and kill function.

6.2.10 Unintentional pressure build-up in the manifold buffer chambers downstream of the chokes shall be avoided.

Guidance note:

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

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6.2.11 Pressure rating of the overboard lines and associated valves shall not be less than the pressure rating of the manifold buffer chambers downstream of the chokes.

6.2.12 Mud/gas-separator and liquid seal shall be fitted with adequate pressure monitoring. The liquid seal shall prevent gas from flowing to the active mud system.

The gas vent line shall not have any restrictions, nor connections to other systems.

Guidance note:

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

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

The following recommendations apply for normal drilling operations (i.e. 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 or 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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6.2.13 Mud/gas-separator shall be vented to a safe location.

Guidance note:

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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6.2.14 Choke and kill systems shall be designed to withstand erosion for the specified design life of the system/equipment.

Guidance note 1:

Erosion analysis may be used to document sufficient erosion capacity.

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Guidance note 2:

Directional changes in piping should be done using large radius pipe bends. Short radius bends, elbows, ells and tees should have flow targets or fluid cushions.

See API Standard 53 for definition of large radius pipe bends, and for further guidance.

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6.2.15 Provisions for hydrate prevention shall be installed where relevant.

6.2.16 Control and monitoring

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

6.2.16.2 At least one remote control station shall be situated such that it is shielded if any leakages from manifold and associated manifold components should occur.

6.2.16.3 Where manual operation of chokes in manifold is possible, indications important for such operations shall be available for operator.

Guidance note:

E.g. indications for pressure, temperature, choke position.

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7 Drilling riser systems

7.1 Introduction

7.1.1 Drilling riser systems shall provide a conduit for drilling fluid circulation and guide tubulars in/out of well.

7.1.2 This subsection describes requirements for drilling riser systems, including equipment such as, but not limited to:

— marine riser joints (including flex joints, slip-joints, termination joints)
— surface riser joints
— control and monitoring systems.

7.1.3 Drilling riser systems shall be capable of preventing, or support the prevention of, relevant hazardous events from occurring. If occurred, the system shall mitigate, or support the mitigation of, the consequences of such an event.

The following hazardous events are considered in this subsection:

— blowout
— blowout (without BOP installed)
— riser gas release.

7.1.4 Categorisation for operative barrier functions, and their corresponding safety functions (and systems, where relevant), shall be as provided in Table 6 for the hazardous events in [7.1.3].

Table 6 Barrier function categorisation for drilling riser systems

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		
Pressure containment - Maintain structural integrity (main pipe and circumferential lines)	Important	Shut in well (WSD system)	Blowout
Maintain structural integrity for running of BOP	Essential	1)	Dropped load
Providing conduit for diverting well influx overboard	Essential	1)	Blowout (without BOP installed), riser gas release
Providing conduit for mud circulation	Important	Shut in well (WSD system)	Blowout

1) With respect to structural integrity, required safety and integrity may be obtained through design, manufacturing and maintenance of the operative barrier.

Guidance note:

For WSD systems, see [4].

For general hazards (e.g. accidental release of pressurized fluids), see Sec.5 [2].

For general requirements and description of barriers and functions, see Sec.1.

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

7.2 Operative functions/systems

7.2.1 Drilling risers shall be designed to withstand applicable combined design loads relevant for their application.

Guidance note:

Relevant loads to evaluate include:

- riser tensional loads and load variations
- motion loads
- drilling fluid specific gravity (SG)
- handling loads
- wind
- well shut-in pressures (for high pressure risers)
- collapse pressure (for marine risers)
- waves (for marine risers)
- current (for marine risers)

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

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

Guidance note:

See [3] for requirements to MPD systems.

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7.2.3 Riser bolts shall be in accordance with Sec.2 [2.6.1].

Guidance note:

For charpy V-notch impact value requirements, see Sec.2 [2.6.1.4].

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

7.2.4 Marine drilling risers

7.2.4.1 Charpy V-notch impact value requirement specified in Sec.2 [2.6.1] applies.

For the circumferential lines (P-lines), the Charpy impact value requirement specified in Sec.2 [2.6.2] applies, unless the lines are part of the structural capacity of the riser, in which Sec.2 [2.6.1] applies.

7.2.4.2 Load sharing marine risers shall be designed to withstand standard load cases listed in [7.2.1] and should be completed by characteristic load cases, possibly including, but not limited to:

— bending in weak and strong axis
— asymmetrical tension in the P-lines due to different pressure and temperatures
— non-constant share of load carried by the main pipe and the P-lines due to different properties of materials and or flexible supports of P-lines.

Resulting stresses shall be within allowable stress limits given by applicable recognised standard.

Guidance note:

Global riser analysis should give due consideration to the axial stiffness, bending stiffness, different tensions in the P-lines, etc.

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7.2.5 Surface drilling risers

Charpy V-notch impact value requirement specified in Sec.2 [2.6.1] applies for risers installed below the BOP, while Sec.2 [2.6.2] applies for risers installed above the BOP.

8 Well test systems

8.1 Introduction

8.1.1 Well test systems shall safely process formation returns in order to evaluate formation properties.

8.1.2 This subsection describes requirements for well test systems, including equipment such as, but not limited to:

— surface flow/test tree
— choke manifold
— heat exchanger
— separator
— burner boom.

8.1.3 Well test systems shall be capable of preventing, or support the prevention of, relevant hazardous events from occurring. If occurred, the system shall mitigate, or support the mitigation of, the consequences of such an event.

The following hazardous events are considered in this subsection:

— blowout
— fire and/or explosion.

8.1.4 Categorisation for operative barrier functions, and their corresponding safety functions (and systems, where relevant), shall be as provided in Table 7 for the hazardous events in [8.1.3].

Table 7 Barrier function categorisation for well test systems

Operative barrier functions		*Corresponding safety function (system)*	*Related hazard*
Description	*Categorisation*		
Controlled release of formation fluids	Important	Shut in well (WSD system)	Blowout
	Important	Shut in well and depressurize well test system (Well test PSD/ESD system, MODU/OI ESD system)	Fire and/or explosion
Controlled processing of returned fluids	Important	Shut in well (WSD system)	Blowout
	Important	Shut in well and depressurize well test system (Well test PSD/ESD system, MODU/OI ESD system)	Fire and/or explosion
Pressure containment - Maintain structural integrity	Important	Shut in well (WSD system)	Blowout
	Important	Shut in well and depressurize well test system (Well test PSD/ESD system, MODU/OI ESD system)	Fire and/or explosion

Guidance note:

For WSD systems, see [4].

For well test PSD/ESD systems, see DNVGL-OS-E201.

For MODU/OI ESD systems, see DNVGL-OS-A101 Ch.2 Sec.4 and DNVGL-OS-A101 Ch.2 Sec.6.

For hazards related to heave compensation during well test, see Sec.6 [3].

For general hazards (e.g. accidental release of pressurized fluids), see Sec.5 [2].

For general requirements and description of barriers and functions, see Sec.1.

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8.1.5 This standard applies only to well testing of limited duration. Extended well testing (EWT) shall be considered on a case-by-case basis.

Guidance note:

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

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8.1.6 For requirements to supporting/utility systems, see also other sections in this standard.

8.2 Operative functions/systems

8.2.1 The following aspects shall be thoroughly evaluated for suitability, prior to installation of a well test system with associated equipment:

— area classification
— location assessed in relation to air intakes, lifeboats, control room, escape routes, dropped loads, etc.
— passive and active fire protection
— drain system
— fire and gas detection system
— ESD/PSD and safety philosophy
— deck loading
— sea fastening of equipment
— utility systems.

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

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

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

8.2.5 Interconnecting piping systems 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.

8.2.6 Rotary hose shall not be a part of the test line.

8.2.7 Two valves in series shall be installed where it is possible to bypass pressure reducing devices (e.g. chokes).

8.2.8 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.

8.2.9 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.

8.2.10 A check valve shall be installed in the final flow segment (i.e. upstream heat exchanger, separator).

8.2.11 Air compressors and other utility components shall be suitable for installation in zone 2 areas, or equivalently protected.

8.2.12 Where used, compressed air supply from MODU/OI to burner assemblies shall be designed so as to prevent hydrocarbon contamination of the compressed air systems. Gas detectors shall be installed in air intakes.

8.2.13 Flare lines shall be of hard piping.

Valves diverting flow to separate flare lines shall be interlocked, so that one flare line is always open.

8.2.14 The flare burners shall be located at a safe distance from the MODU/OI, and this distance shall be justified by heat intensity calculations based on worst wind calculations.

8.2.15 Arrangements for cooling of flare burners shall be available where required.

8.2.16 Main process equipment area shall be bunded to prevent any oil spillage from spreading outside the dedicated process area.

Requirements for drainage in DNVGL-OS-E201 Ch.2 Sec.2 shall be applied.

8.2.17 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.

8.3 Safety functions/systems

8.3.1 Depressurization (blowdown) shall be according to DNVGL-OS-E201.

8.3.2 Well test PSD/ESD system shall be according to DNVGL-OS-A101 Ch.2, DNVGL-OS-D201 Ch.2 and DNVGL-OS-D202 Ch.2.

8.3.3 A production flow inlet valve shall be installed. The valve shall be able to operate from both well test PSD/ESD system and MODU/OI ESD system. The valve shall close in case of failure (safe state close) and be designed for fire exposure. Valve position indication shall be available for well test system operator.

8.3.4 An isolation valve shall be installed on the well test system inlet. The valve shall be able to operate from the well test PSD/ESD system. The valve shall close in case of failure (safe state close).

8.3.5 Alarm for well test PSD/ESD shutdown shall be provided in MODU/OI main control room. Shutdown of well test system shall be available from MODU/OI main control room.

8.3.6 Where piping installations include a change of pressure rating ("spec. break"), the lower rated pipe shall be adequately protected against overpressure.

8.3.7 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.

8.3.8 Where double PSV's are used, each shall provide 100% capacity. Isolation valves for PSV's shall be interlocked or locked open, as appropriate.

8.3.9 For capacity requirements of fire water or deluge system for well test area, see DNVGL-OS-D301 Ch.2 Sec.6.

SECTION 8 MANUFACTURING, WORKMANSHIP AND TESTING

1 Introduction

1.1 Scope and application

1.1.1 This section provides requirements to manufacturing, workmanship and testing of drilling systems providing safety, essential or important functions.

1.1.2 Drilling systems shall be manufactured, examined and tested according to this section and applied codes and standards.

1.2 Structure

This section is structured as follows:

— [1]: General introduction.
— [2]: Requirements to manufacturing and workmanship, including welders, welding and heat treatment.
— [3]: Specifies the various tests required by this standard.
— [4]: Specifies in which test phase the tests in [3] shall be performed.

2 Manufacturing and workmanship

2.1 Quality assurance and quality control

Manufacturer shall utilise necessary production facilities, qualifications, procedures, and personnel to ensure that systems/equipment are manufactured to specified requirements.

2.2 Marking

Equipment shall be clearly marked with identification and serial number which relates the equipment to certificates and manufacturing documentation.

Guidance note:

Low stress stamping might be required for certain materials. Paint markings might be accepted, but care should be exercised during handling and storage to preserve the identification.

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2.3 Qualification of welders

2.3.1 Welding of special area, primary structural members/equipment components and pressure-containing/retaining components shall be carried out by qualified welders only.

2.3.2 Qualification of welders shall be in accordance with DNVGL-OS-C401 Ch.2 Sec.3 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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2.3.3 The manufacturer shall supply each qualified welder with an identification number, symbol or similar to enable identification of welding performed by that particular welder on special area, primary structural members/equipment components and pressure-containing/retaining components.

Guidance note:

This may be facilitated by the use of a weld log, containing information such as welder ID, WPS used, weld completed date/time, weld repairs, etc.

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2.4 Welding

2.4.1 Welding of special area, primary structural members/equipment components and pressure-containing/retaining components shall be performed according to an approved welding procedure specification (WPS).

One of the following standards shall be fulfilled, DNVGL-OS-C401 or ISO 15614, alternatively AWS D1.1 or equivalent standard.

Approval shall also include any other equipment/structure, when welded towards special area, primary structural members/equipment components and pressure-containing/retaining components.

Overlay/clad welding and wide gap welding shall be qualified as required in DNVGL-OS-C401 Ch.2 Sec.5.

Guidance note:

The scope of this standard covers 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).

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2.4.2 For butt welded joints of the full penetration type, special provisions shall be taken to ensure a high quality of the root side.

Guidance note:

For welding workmanship, see DNVGL-OS-C401 Ch.2 Sec.6.

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2.4.3 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.

2.4.4 Repair welding shall be performed according to qualified and approved repair procedures. If the repair depth is beyond 25% of the parent material thickness, the repair welding shall be qualified by a dedicated repair welding qualification test.

Qualification of repair welding procedures shall be based on excavating a repair groove in an original weld (welded in accordance with a qualified welding procedure). The excavated groove shall be of sufficient length to obtain the required number of test specimens, plus 50 mm at each end.

Scope and extent of testing shall be as for butt welds. Charpy V-notch impact test specimens shall be located on the fusion line between the repair weld and the weld metal of the original weld, and on the corresponding heat-affected zone.

Repair welding in the same area shall not be performed more than twice, unless accepted after case-by-base evaluation. Welding consumables for repair welding shall be according to manufacturers recommendation.

2.5 Heat treatment

2.5.1 After forming and/or welding, the component shall be heat treated if required, according to the applied code or standard, or if found necessary in order to maintain adequate notch ductility and avoid hydrogen induced cracking.

2.5.2 Heat treatment shall be performed according to qualified procedures, describing process steps, heat treatment temperatures, heating/cooling rates, time at temperatures and cooling media.

2.5.3 A normalising heat treatment shall be performed for hot formed components, when hot forming has been carried out at a temperature above 700^{C}, unless otherwise agreed.

2.5.4 Heat treatment of cold worked materials shall take into consideration any reduction in yield and tensile strength that may be caused by such heat treatment.

2.5.5 Preheating and/or post weld heat treatment (PWHT) shall be used when necessitated by the dimensions and material composition.

2.5.6 Post weld heat treatment shall, unless otherwise agreed, be performed in a fully enclosed furnace.

Guidance note:

Local PWHT may be performed on simple joints when following a qualified procedure.

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2.5.7 If defects are revealed after heat treatment, new heat treatment shall, unless otherwise agreed, be performed after repair welding of the defects.

2.5.8 A heat treatment procedure associated with forming and/or welding which is not covered by the applied code or standard shall be thoroughly reviewed.

2.6 Pipe bending

2.6.1 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.

2.6.2 Heat treatment procedure in connection with pipe bending shall be independently reviewed if not covered by the applied code or standard.

3 Tests

3.1 Non-destructive testing

3.1.1 General

3.1.1.1 Non-destructive testing (NDT) shall include procedures, extent and acceptance criteria, as required by this section.

3.1.1.2 All testing shall be carried out by qualified and certified personnel (certified personnel is not required for VT).

NDT operators and supervisors shall be certified according to a 3rd party certification scheme based on ISO 9712 or ASNT Central Certification Program (ACCP). The certificate shall clearly state the qualifications as to which testing method, level and within which industrial sector the operator is certified. NDT operators (except for VT inspectors) shall be certified to Level 2 in the testing method and industrial sector concerned.

VT shall be carried out by personnel qualified to a recognized standard. The qualifications shall be documented by the service supplier.

The NDT supervisor shall be available for scheduling and monitoring of the performed NDT, and for developing, verifying and/or approving the NDT procedures in use and make sure these procedures are in compliance with the relevant requirements. NDT supervisors shall, unless otherwise agreed, be certified to Level 3 in the testing method and industrial sector concerned.

Guidance note:

SNT-TC-1A may be accepted if the NDT Company's written practice is reviewed and accepted. The suppliers written practice shall as a minimum comply with ISO 9712, except for the impartiality requirements of a certification body and/or authorized body.

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3.1.1.3 Final inspection and NDT of welds for structural members, mechanical, pressure-containing and pressure-retaining components shall be carried out at least 48 hours after completed welding, except where post-weld heat treatment (PWHT) is required. When PWHT is performed, final NDT shall be carried out after all heat treatments have been completed.

Guidance note:

Time delay may upon agreement be reduced for materials with yield strength below 420 N/mm^2, if plate thickness is less than 40 mm, and if consistent low failure rate of delayed cracking has been documented for the materials and welding consumables in question.

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3.1.1.4 Final NDT shall be performed prior to any possible process which would make the required NDT impossible, or which could have cause erroneous results (e.g. coating of surfaces).

3.1.1.5 If the NDT reveals a defect requiring repair, additional testing shall be carried out in accordance with the applied code or standard, unless otherwise justified.

3.1.1.6 Magnetic particle testing (MT) for the base material is required if the carbon equivalent (C_{eq}) is above 0.45%, determined by the following formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \; (\%)$$

Extent of MT shall be 100% during early stage of manufacturing, in order to prove absence of surface cracks.

3.1.1.7 For custom designed bolts, magnetic particle testing shall be carried out at least 48 hours after completion of final heat treatment and prior to final machining. The testing shall be in accordance with DNVGL-CG-0051 Sec.3.

Cracks (as defined in applied normative reference) are not acceptable, irrespective of crack depth and location.

Surface irregularities other than cracks, which are not covered by applied recognized standard, shall be considered on a case-by-case basis.

Manufacturing and test documentation shall be submitted for review.

3.1.1.8 All performed examination and results shall be systematically recorded and fully traceable.

3.1.2 NDT procedures

3.1.2.1 NDT shall be performed in accordance with written procedures.

The procedures shall as a minimum be in accordance with DNVGL-CG-0051.

Alternatively, according to the following:

— MT according to ASTM E709 (permanent magnets are not accepted, and DC magnetization/DC magnets should be avoided)
— PT according to ASTM E165
— UT according to ASME BVPC Section V.

Guidance note:

Other recognised standards might be accepted on a case-by-case basis.

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3.1.2.2 Procedures shall as a minimum contain detailed information regarding the following aspects:

— applicable code or standard
— materials, dimensions and temperature (if relevant) of tested material
— periodical verification of NDT equipment calibration requirements
— joint configuration and dimensions
— technique (sketches/figures to be referenced in the NDT report)
— equipment and consumables
— sensitivity, and light/viewing conditions for MT, PT and VT
— calibration techniques and calibration references
— testing parameters and variables
— assessment of imperfections and surfaces
— method for reporting and documentation of results (reporting shall ensure that there is no doubt what is tested, where it has been tested, and give a clear and exact description of reportable defect location)
— reference to applicable welding procedure(s).

3.1.3 NDT extent

3.1.3.1 Minimum NDT extent for welds in structural members and mechanical components shall be according to Table 1:

Table 1 Minimum NDT extent for welds in structural members and mechanical components

Category of member/ component	*Types of joint*	*Test method*			
		VT	*MT* 1)	*RT* 2)	*UT* 3)
Special	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%	10%	-

Category of member/ component	*Types of joint*	*Test method*			
	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[4)]	spot[4)]	-
	Cross-and T-joints, full penetration welds	100%	spot[4)]	-	spot[4)]
	Cross-and T-joints, partial penetration and fillet welds	100%	spot[4)]	-	-

1) Penetrant testing to be adopted for non-ferromagnetic materials.
2) May be partly or fully replaced by UT upon agreement.
3) UT shall be performed for welds of thickness 10 mm and above.
4) Approximately 2% to 5%.

3.1.3.2 Surface NDT (MT/PT) of machined surfaces for equipment covered by API Spec 8C (e.g. on drilling hoisting wire sheaves, bearings, shafts, etc.) shall be given special attention and shall be performed and documented in accordance with API Spec 8C.

3.1.3.3 Minimum NDT extent for welds in pressure containing and pressure retaining components (including piping) shall be according to Table 2:

Table 2 Minimum NDT extent for welds in pressure containing and pressure retaining components

Limitations	*Types of joint*	*RT[1)]*	*MT[2)]*
$P \geq 50$ bar or $T \geq 121°C$	L	100%	100%
	C	100%	100%
	B	-	100%
$P < 50$ bar and $T < 121°C$	L	20%	20%
	C	10%	10%
	L+C	20%	-
	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 might be accepted as an alternative. For non-magnetic materials, liquid penetrant method shall be used.

p = pressure [bar]

T = temperature [$°C$]

L = longitudinal

C = circumferential

L+C = crossing between longitudinal and circumferential

B = branches and reinforcement rings.

3.1.4 NDT acceptance criteria

3.1.4.1 Acceptance criteria for structural members and mechanical components shall be in accordance with DNVGL-OS-C401 Ch.2 Sec.7 [6].

Guidance note:

Welding of crown block structure and support may follow API Specification 4F as an alternative to the requirements in [3.1.4].

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3.1.4.2 Acceptance criteria for pressure containing and pressure retaining components shall be in accordance with DNVGL-CG-0051, or as specified in normative design code.

Where acceptance criteria are not specified, the following shall apply:

— Results from radiographic testing shall be graded according to EN ISO 10675-1 (or ISO 5817), and shall at least meet the requirements of Level 1 (or ISO 5817 Quality Level B) for welds where 100% radiographic testing is required, and Level 2 (or ISO 5817 Quality Level C) where random testing (5-10%) is required.
— Results from surface testing (MT/PT) shall at least meet the requirements of Acceptance Level 1 of EN ISO 23278 for MT and EN ISO 23277 for PT.

3.2 Testing of weld samples

3.2.1 Mechanical testing of weldments shall be carried out in accordance with DNVGL-OS-C401 or the applied code or standard. Acceptance criteria for charpy shall be according to Sec.2.

3.2.2 Where manufacturer is not able to document conformity to welding requirements, or where irregularities in weld fabrication are found (in relation to criteria, see [3.1.4]), a fabrication welding production test (WPT) shall be performed. The WPT shall provide documentation of conformity to welding requirements.

Welding parameters and environmental conditions for the WPT shall be as for the actual weld. Failure of a WPT shall lead to a review of the welding performed in order to identify reason for failure and establish appropriate corrective actions.

Guidance note:

Requirements for WPT are in general the same as for the relevant welding procedure qualification test (WPQT).

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3.3 Pressure testing

3.3.1 Pressure containing components (including piping) shall be subject to a hydrostatic pressure test.

Test pressure shall be 1.5 × design pressure, unless otherwise specified in normative codes and standards.

Guidance note 1:

This requirement may be exempted for small bore piping (2" and below) for instrumentation and similar, 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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Guidance note 2:

For manifolds where all individual components have been pressure tested to 1.5 x design pressure, the assembly pressure test may be done at design pressure.

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Guidance note 3:

Where hydrostatic pressure testing of piping represents particular problems, alternative suitable test methods may be applied where justified as suitable.

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3.3.2 Holding time shall be minimum 15 minutes after the pressure has been stabilised, unless otherwise specified in normative codes and standards.

A shorter holding time is accepted for small bore piping/components (2" and below) when allowed by normative codes and standards.

3.3.3 The pressure shall be measured such that it can be monitored during the test, and both pressure and holding time results shall be systematically recorded and documented so as to be fully traceable.

Guidance note:

This is normally done by installing a pressure gauge/transducer for monitoring, and an analog chart recorder/digital acquisition system or similar for recording.

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3.3.4 For large systems and systems that is divided into separate deliveries, it shall be documented how the complete system is pressure tested.

3.4 Overload testing

3.4.1 All lifting appliances shall be tested in "as installed" condition prior to first use.

3.4.2 The test load applied to a lifting appliance shall exceed the safe working load (SWL) of the appliance according to Table 3:

Table 3 Test load for lifting appliances

SWL (in metric tonnes, t)	*Test load*[1)]
SWL ≤ 20 t	1.25 × SWL
20 t < SWL ≤ 50 t	SWL + 5 t
SWL > 50 t	1.1 × SWL
Man-riding equipment	2 × SWL
1) Where the dynamic factor ψ exceeds 1.33, the reference SWL in the table shall be taken as 0.75 x ψ x SWL.	

Guidance note:

Where justified in applied recognised code or standard (e.g. API Spec 4F for derrick, API Spec 8C for drilling hoisting) system/equipment may be accepted without overload test.

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3.4.3 The test load applied to loose gear shall exceed the safe working load (SWL) of the loose gear as follows:

Table 4 Test load for loose gear and other accessories

SWL (in metric tonnes, t)	*Test load*[1)]
Chains, hooks, shackles, swivels, etc.:	
SWL ≤ 25 t	2 x SWL
SWL > 25 t	(1.22 x SWL) + 20
Multi-sheave blocks: [3)]	
SWL ≤ 25 t	2 x SWL
25 t < SWL ≤ 160 t	(0.933 x SWL) + 27
SWL > 160 t	1.1 x SWL
Single-sheave blocks: [2) 4)]	4 x SWL
Lifting beams, etc.:	
SWL ≤ 10 t	2 x SWL
10 t < SWL ≤ 160 t	(1.04 x SWL) + 9.6
SWL > 160 t	1.1 x SWL

1) Where the dynamic factor ψ exceeds 1.33, the reference SWL in the table shall be taken as 0.75 x ψ x SWL.
2) For single sheave blocks, the SWL shall be taken as one half of the resultant load on the head fitting.
3) For multi-sheave blocks, the SWL shall be taken as the resultant load on the head fitting.
4) For single sheave blocks, with a permissible load at the head fitting exceeding 25 tonnes, the test load may be reduced as permitted for the chains, hooks, shackles, swivels, etc. in the table. In this case the SWL notation shall be the resultant load on the head fitting.

3.4.4 Built-in sheaves, hook blocks, lifting beams and other items dedicated to the lifting appliance are not considered loose gear and will be accepted when overload tested as required for the lifting appliance (see [3.4.2]). These items shall be marked with SWL.

3.4.5 Pad eyes, lifting lugs, brackets and similar for regular or maintenance lifting shall be tested in accordance with the applied design code, however the test load shall not be less than that specified in Table 3.

Pad eyes, lifting lugs, brackets and similar within this category shall be marked SWL.

Guidance note:

Skids, lifting lugs, brackets and similar for installation lifting only, do not require load testing. Means shall be provided to avoid use of such brackets for regular lifting.

Skids, lifting lugs, brackets and similar within this category should not be marked SWL.

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3.4.6 Man-riding equipment

3.4.6.1 Static brake capacity test at 2 × SWL shall be performed for all brakes when operating simultaneously.

3.4.6.2 Static brake capacity test at 1.8 × SWL shall be performed for each individual brake.

3.4.6.3 Dynamic brake capacity test at 1.25 × SWL shall be performed for each individual brake.

Dynamic brake capacity test shall, unless otherwise agreed, be performed with full lowering speed and quick stop (e.g. release control rapidly/push emergency stop).

3.4.7 Equipment with test load, shall be hoisted, slewed, luffed and travelled at slow speed through the entire operating range, as applicable for the lifting appliance in question.

Lifting appliances on tracks, including their trolleys (as applicable), shall be traversed and travelled over the full length of their track.

Guidance note:

E.g. gantry/travelling cranes, pipe rackers, standbuilding arms, laydown systems, etc.

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3.4.8 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.

3.4.9 All items of loose gear and accessories (e.g. shackles, blocks, hooks, etc.) with a SWL larger than 500 kg, which have not been subject to design review, shall be overload tested to 200% of SWL and thoroughly examined prior to use.

3.4.10 Flare boom shall be tested with an overload of 25% related to the required weight of burner and spreader. The overload test shall demonstrate that the boom is capable of carrying out motions such as slewing, hoisting etc. as relevant.

3.4.11 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.

3.5 Function testing

Function testing shall be performed to demonstrate that systems and equipment can be operated as described by manufacturer and in accordance with applicable requirements of this standard.

Function tests shall also include a degree of performance testing outside of the normal operating parameters (but within design parameters). Testing/verification of safety functions/systems shall be performed, including emergency operation (as applicable).

3.6 Failure testing

3.6.1 Failure testing shall be performed to demonstrate that systems and equipment reacts to failures as described by manufacturer, and in accordance with applicable requirements of this standard.

Guidance note:

Typical failures to be considered are provided in DNVGL-OS-D202 Ch.2 Sec.1 [3].

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3.6.2 The test program shall include tests to verify safeguards, assumptions and expected responses made in FMEA (as applicable).

Guidance note:

See Sec.1 [3.3.2.8], Sec.1 [3.3.3.6] and Sec.1 [3.4.1.18].

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3.7 Testing of electrical systems

Testing of electrical systems shall be according to DNVGL-OS-D201 (as applicable), and as provided in this standard.

3.8 Testing of control and monitoring systems

Testing of control and monitoring systems shall be according to DNVGL-OS-D202 (as applicable), and as provided in this standard.

4 Test phases

4.1 Testing before system/equipment delivery

4.1.1 Component and hardware testing

4.1.1.1 Components and hardware shall be verified and tested to demonstrate that systems and equipment fulfil the requirements of this standard.

4.1.1.2 Scope shall as a minimum include the following (as applicable):

1) Verification of manufacturing records.
2) Verification of mechanical and structural components.
3) NDT according to [3.1].
4) Testing of weld samples according to [3.2].
5) Pressure testing according to [3.3].
6) Overload testing, if required by applicable normative code (e.g. proof load test).
7) Testing of electrical systems according to [3.7].
8) Verification of hardware in control and monitoring systems according to [3.8].

Guidance note:

Function testing according to [3.5] and failure testing according to [3.6] is described in [4.1.2].

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4.1.1.3 Testing shall be performed according to written test programs.

4.1.1.4 Blowout preventers (including their control) 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 tubular to be used, and subsequent successful sealing (as applicable). Which tubulars a shear ram is qualified for shearing/ sealing, shall be specified and documented.

Calculations shall be supported by submitting shear test data (e.g. from prototype tests, if applicable).

4.1.2 System testing

4.1.2.1 System testing is function- and failure-testing which shall be performed to demonstrate that systems and equipment fulfil the requirements of this standard.

4.1.2.2 Scope shall as a minimum include the following:

1) Function testing according to [3.5] (including testing of all safety functions).
2) Failure testing according to [3.6] (including FMEA testing, where relevant).
3) Verification of system settings, such as adjustment of controllers and system calibration of sensors and alarms.

4.1.2.3 Systems/equipment shall be tested under working conditions (or equivalent), according to a written test program.

4.1.2.4 If the tests described in [4.1.2] are not completed before the system/equipment is delivered, the testing shall be planned for and described in a test plan, detailing how the tests are to be performed and who is responsible.

In such cases, all contracting parties shall agree on the plan.

4.1.2.5 For software dependent systems/equipment, providing safety functions or essential functions, the following shall also apply:

1) System testing shall be performed as simulator-based testing in accordance with [4.1.3], unless required system acceptance testing can be performed on the complete system, as built.

    Guidance note:

    Software dependent systems/equipment providing essential or safety functions are e.g. active-heave drilling hoisting systems (e.g. active-heave drawworks) and BOP multiplex (MUX) systems.

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2) System tests shall include the entire control and monitoring system, integrating all hardware and software.
3) System tests shall be performed with the software installed on the actual hardware to be used onboard.

    Guidance note:

    Hardware replica might be accepted on a case-by-case basis.

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4.1.3 Simulator-based testing

4.1.3.1 General

Simulator-based testing shall, when applied, provide objective evidence of required functionality (during normal, abnormal and degraded condition) of the specified target control system (operative essential/safety).

Scope shall as a minimum be as specified in [4.1.2.2].

4.1.3.2 Simulator test setup

Simulator-based testing shall be performed on the actual control system hardware to be installed.

Guidance note:

Hardware replica might be accepted on a case-by-case basis.

Cloud-based testing by use of soft-PLC might also be accepted.

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Simulator shall run on a control unit that is separate from the control system.

Testing shall be performed on released software revisions for both simulator and control system(s).

Testing shall be performed according to a Simulator test program, and on the test setup and software that was validated through the Simulator validation test program.

4.1.3.3 Simulator framework

All relevant I/Os shall be interfaced between control system and simulator. Any ignored/not interfaced signals shall be identified before test is started.

It shall be possible to monitor and/or trend all I/O-signals between simulator and control system.

It shall be possible to simulate typical control system failures to the system, such as broken wire, value out of range, noise on signals, command errors (functions being executed without being commanded), execution errors (functions not being executed when commanded etc.

The simulator shall be adequate for the type of failures intended to be tested.

Guidance note:

Failures may either be introduced by manipulating the command or sensor signal.

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4.1.3.4 Simulator accuracy

Simulator and control system shall run in a closed-loop configuration. Simulator output shall render a real-life behaviour of the control system.

Simulator response shall be in the correct range, e.g.:

1) Speed of a cylinder movement is in the correct range.
2) Dead bands for hydraulic valves are correctly simulated.
3) Accelerations are in the correct range when e.g. testing heave compensated drawworks.

It shall be possible to execute all functions in the target control system, with minimum manual manipulation of simulator signals.

4.1.3.5 Simulator validation

Simulator-based test setups shall be validated by validation tests, demonstrating adequacy/suitability for the purpose (test objective), and that it does not mask errors in the target control system.

Before validation testing is performed, it shall be verified that there are no active/ignored/suppressed alarms in the system that may impact the testing.

Guidance note:

Key element for planning of the validation activities is to analyse the test objective and identify possible factors/elements in the test setup which might invalidate the test results. A set of relevant validation activities for the test setup should be identified, and measures for limiting possible inaccuracies and uncertainties should be described.

A possible cause of masking errors in the target system could be if a parameter is copied directly from the target system into the simulator configuration. If the parameter is wrong, it will be wrong in the simulator as well, making it difficult to identify errors when both the target system and the simulator is using the same erroneous parameter value. Likelihood of such masking can be reduced if the simulator configuration is performed independently from the target system configuration. Performing simulator configuration tests independently from the target system can also decrease the likelihood of such errors.

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4.2 Onboard testing

4.2.1 Commissioning

4.2.1.1 Commissioning shall be performed to demonstrate that systems and equipment fulfil the requirements of this standard.

4.2.1.2 Commissioning shall as a minimum include the following:

1) Demonstrate, verify and document full functionality of all systems according to [3.5].
2) Overload test according to [3.4].
3) For equipment not subjected to overload test, functional testing shall be performed at rated load (unless otherwise agreed).

   Guidance note:

   For equipment where function testing at rated load has been rendered impossible (e.g. due to very high load rating), alternative testing methods might be accepted on a case-by-case basis if presented at an early stage.

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4) Testing of all safety functions.
5) Pressure test according to [3.3], with maximum operating pressure as test pressure.
6) Any required test which was not completed before system/equipment delivery.
7) Verification of system settings, such as adjustment of controllers and system calibration of sensors and alarms.

4.2.1.3 The complete system/equipment shall be tested under working conditions (after installation) in accordance with an approved test program.

Guidance note:

Test responsible should provide an overview of sub-items/sub-systems, pending testing/comments/certification, etc.

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4.2.1.4 For systems/equipment providing essential, important or safety functions, the following also applies:

1) Verification of correct function of individual equipment packages, together with establishment of correct parameters for automation and safety (time constants, set points, etc.), including the ability of the automation and safety systems to keep any EUC within the specified tolerances and carry out all safety/protective actions.
2) Verification of the correct distribution, protection and capacity of power supplies.
3) Verification of back-up and emergency functions for essential and safety functions.

4.2.2 System integration testing

Systems integrated into a common control system, or systems that interacts in automatic or semi-automatic mode of operation, shall be tested in an integration test to demonstrate that the systems fulfil the requirements of this standard.

CHAPTER 3 CERTIFICATION AND CLASSIFICATION

SECTION 1 INTRODUCTION

1 General

1.1 Introduction

As well as representing DNV GL's interpretation of safe engineering practice for general use by the offshore industry, the offshore standards also provide technical basis for DNV GL classification and certification.

1.2 Structure

This chapter is divided into three sections:

— Sec.1: Explains how this standard shall be applied for offshore classification and/or certification.
— Sec.2: Identifies documentation requirements when using this standard for classification and/or certification.
— Sec.3: Provides certification requirements for systems and equipment when using this standard for classification and/or certification.

2 Certification and classification principles

2.1 General

2.1.1 A description of principles, procedures, class notations and technical basis for offshore classification is provided in DNVGL-RU-OU-0101.

Guidance note 1:

Other class notations might affect the design and manufacturing of systems/equipment covered by this standard, e.g.:

— **CLEAN**

(e.g. requirements to drip trays, refrigerants, etc.)

— **CLEAN(Design)**

(e.g.inventory of hazardous materials (IHM), material declarations (MD), and

CLEAN

requirements)

— **Winterization**

(e.g. requirements to minimum design temperature, T_w).

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Guidance note 2:

Materials delivered to this standard do not have to come from works approved by DNV GL, see DNVGL-OS-B101 Ch.3 Sec.1.

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2.1.2 Drilling facilities will be classified and certified based on the following main activities:

— design verification
— manufacturing survey and testing
— issuance of certificate
— for classification: installation survey and testing (onboard/integration tests).

2.1.3 For requirements to classification in operation, see DNVGL-RU-OU-0300.

Guidance note:

To enable advanced condition monitoring and remote inspection in operation, it is recommended that the operator/owner of the drilling facility establishes a data management system and defines the relevant data requirements, to include these requirements in its specifications for design and construction.

DNVGL-RP-0497 may be used for further guidance.

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2.1.4 Any modifications, deviations, exceptions or alternative solutions to the requirements of this standard shall be documented and accepted by DNV GL.

2.1.5 Where codes and standards do not call for specific extent of inspection and testing, the inspection and testing scope shall be agreed between contracting parties and DNV GL.

2.2 Class designation

MODUs/OIs fitted with drilling facilities that have been designed, manufactured, installed and tested in accordance with the requirements of this standard, under supervision of DNV GL, will be entitled to the class notation **DRILL**.

For existing technology and operations, the generic hazardous events are suitable and complete and the above condistion is met by complying with the prescriptive requirements of thhis standard.

Guidance note:

For further details on class scope for **DRILL**, **DRILL(MPD)**, **DRILL(MPD-ready)** and **DRILL(US)**, see DNVGL-RU-OU-0101. For **DRILL(N)**, see DNVGL-SI-0166.

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2.3 Assumptions

Classification is based on the assumption that the drilling facilities will be properly maintained and operated in accordance with manufacturer's/owner's recommendations within specified design limits.

2.4 Loads

Consideration of earthquake loads as listed in Ch.2 Sec.2 is excluded from scope of classification.

2.5 Risk assessments

2.5.1 DNV GL shall attend FMEA risk assessments where such are required (see Ch.2 Sec.1 [3.3.2.8], Ch.2 Sec.1 [3.3.3.6] and Ch.2 Sec.1 [3.4.1.18]), unless otherwise agreed.

2.5.2 Scope and extent of qualification of novel technology (see Ch.1 Sec.1 [1.3.3]) for certification and/or classification to this standard shall be agreed before start of process.

Guidance note:

Normally this would as a minimum include attendance at risk assessment workshops.

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2.6 Design validation/verification testing

Design validation tests and design verification tests, as required by normative references, shall be witnessed by DNV GL.

3 Voluntary services

3.1 Systems/equipment not subjected to classification

3.1.1 This standard may also be applied to certify drilling systems and equipment which are not subjected to classification. The procedure for certification category I in Sec.3 [1.1.4] may be followed, resulting is issuance of DNV GL product certificate(s).

Guidance note:

Both Certification category I and category II systems/equipment, as provided in Sec.3, may be subjected to certification.

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3.1.2 Where product certification is not requested, scope may be limited to design review and issuance of DNV GL design verification reports and/or DNV GL type approval certificates.

3.1.3 Approval of test procedures and/or witnessing of activities, such as testing before delivery and onboard testing may be performed and documented by issuance of DNV GL survey statement(s).

3.2 Certificate for drilling hoisting

Certificate for drilling hoisting (CGDR) may be issued for all category I lifting equipment covered by this standard upon satisfactory installation, survey and testing onboard.

CGDR shall contain clear references to all DVRs/TAs and PCs on which the certificate is based, and shall state testing and survey carried out.

SECTION 2 DOCUMENTATION REQUIREMENTS

1 General

1.1 Introduction

1.1.1 This section provides documentation requirements for approval of systems and equipment subjected to classification and/or certification.

Guidance note:

Documentation requirements are based on standardised documentation types. Definitions of the documentation types are given in DNVGL-RU-SHIP Pt.1 Ch.3.

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1.1.2 Further to the documentation requirements specified, documentation requirements of normative standards shall also be provided.

Guidance note:

For normative standards, see Ch.1 Sec.1 [3].

Duplication should be avoided.

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1.2 Symbols

Symbols used shall be explained, or reference to a standard code given.

Guidance note:

E.g. ISA 5.1 or ISO 3511.

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1.3 Risk assessments

For safety systems and systems providing essential/important functions, risk assessment reports shall be submitted to the DNV GL.

Guidance note:

See also Sec.1 [2.5].

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1.4 Pipe stress and flexibility analysis

Where required, pipe stress and flexibility analysis shall be documented according to DNVGL-RP-D101 [3.17].

1.5 Finite element analysis

1.5.1 When finite element analysis is submitted, the requirements of this subsection shall apply.

1.5.2 When either 2D or 3D elements are used, and when the applicable reference standard only has requirements for nominal stress levels, then recognised tools shall be used to calculate the membrane stress and the bending stress. Membrane plus bending shall be equal to, or lower than, the acceptable nominal stress.

Guidance note:

This requirement is not applicable for codes/standards with specific acceptance criteria for finite element analyses.

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1.5.3 Boundary conditions shall be clearly defined and motivated in the design documentation. The closer the boundary conditions are to areas of interest, the more physically correct they have to be.

1.5.4 Applied loads shall be clearly defined and motivated in the design documentation.

1.5.5 Material models used shall be clearly defined in the design documentation.

1.5.6 Mesh quality shall be in accordance with applicable codes/standards.

Guidance note:

See e.g. DNVGL-RP-C203 for fatigue evaluations and DNVGL-RP-C208 for non-linear analyses.

When a mesh sensitivity analysis show a difference between element and nodal results to be <10%, then the mesh density is ok unless the applicable reference standard has specific requirements.

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1.5.7 Contact conditions shall be correctly modeled.

100% bonded connections are not allowed for parts connected by fillet welds.

Surfaces which can slide against each other shall be modeled correctly and/or by conservative assumptions which shall be motivated in the design documentation.

2 Classification

2.1 General

Documentation requirements for design and construction will be provided by DNVGL in accordance with the codes and definitions in DNVGL-RU-SHIP Pt.1 Ch.3 Sec.4.

Guidance note:

For documentation requirements to certification, see [3], , for requirements to specific systems see [2.2].

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2.2 Documentation for specific systems

2.2.1 Managed Pressure Drilling (MPD) systems

A functional design specification for the MPD system shall be submitted for review. It shall as a minimum contain the following:

— functional description, including interfaces/connections to the rig and to other systems
— main parameters (i.e. max pressure rating of equipment, max tension capacity, max flow capacities, accuracy in bottom-hole pressure adjustment (ΔP), lowest influx detection volume, max water depth, relief system capacity, etc.)
— P&IDs, clearly showing arrangement of MPD piping and components
— vessel P&IDs, showing modifications and MPD tie-ins to vessel specific equipment and piping
— well control matrix, documenting criteria for when to activate systems/equipment (barriers)
— set-point pressure philosophy for MPD system and pressure relief system
— an overview of the components and their compatibility with the environment
— description of sources and potential grade of release as basis for hazardous zones

— hazardous area classification drawings
— updated fire protection and detection descriptions
— updated cause & effect diagrams
— inspection and test plans
— test procedures (e.g. commissioning)
— risk assessment reports.

2.2.2 Diverter systems

An erosion analysis shall be submitted.

Guidance note:

Analysis should be according to DNVGL-RP-O501 or equivalent.

See also Ch.2 Sec.7 [5.2.5].

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2.2.3 Well test systems

A functional design specification for the Well test system shall be submitted for review. It shall as a minimum contain the following:

— functional description, including interfaces/connections/isolation to the MODU/OI and to other systems
— system layout
— hazardous area classification drawing
— heat radiation analysis
— wind speed and direction
— equipment securing and deck support
— blow down system description
— P&IDs
— firefighting system arrangement
— shut down system description
— pressure test procedure
— electrical power supply drawing
— fire & gas detection system drawing
— fire safety of containers
— bunding drawing
— escape routes drawing
— lifting over the well test system
— piping, valves and component documentation
— equipment certification
— pressure calculations
— blow down calculations (to consider accidental fire load)
— gas dispersion calculations
— cooling calculations
— structural calculations
— equipment calculations.

Guidance note:

For details, see DNVGL-OTG-11.

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3 Certification

3.1 General

3.1.1 This subsection describes general documentation requirements for systems and equipment subjected to certification.

Guidance note:

Documentation might also have to be submitted for classification (typically to yard/owner) according to agreement. E.g. Ex-lists and product certificates for systems/equipment (cat.I and cat.II).

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3.1.2 Structural and mechanical equipment

A documentation package shall be submitted, containing as a minimum the following (as applicable):

Table 1 Structural and mechanical equipment documentation

Document description	*Document content*
Functional design specification	Description of design basis/philosophy and design criteria, including (as applicable): — design principles applied — applied rules, standards and codes — description of all operative functions incorporated in the system and their technical realisation — description of all interfaces towards other systems and their technical realisation — description of all safety functions incorporated in the system — safe states if the operative system should fail, e.g. normally energised and normally de-energised circuits — requirements to the system in order to maintain an acceptable level of safety — dangerous operations and requirements to corresponding manual actions — applied loads, static and dynamic — rating with respect to power, temperature, pressure, etc. — environmental conditions — requirements to maintenance.
Assembly or arrangement drawings	A drawing showing how the parts of a mechanical assembly are arranged together.
Detailed drawings	A drawing showing geometric dimensions, scantlings and arrangement of the object. The drawing shall include: — details of parts — material specifications — for important components of welded construction, full details of joints, welding procedures, filler metal particulars and heat treatment after welding specification — fabrication tolerances.

Document description	*Document content*
Material specification	A document describing: — scope, references (applied material standard) and definitions — production process, delivery condition and chemical composition requirements — mechanical testing and requirements — inspection and non-destructive testing — repair — dimensions and tolerances — surface protection — certification and marking.
Design analyses (according to design code)	A document providing: — objectives — premises — assumptions — conclusions relating to analysis of: — static strength — dynamic strength — vibration. Equations used shall have references to relevant design codes/standards. Measurements used shall have references to relevant detail drawings.
Non-destructive testing (NDT) plan	A document describing the methods, extent and criteria for the non-destructive testing that shall be performed.
Test procedure	A document describing the test configuration and test methods for testing at before delivery, specifying for each test: — initial condition — how to perform the test — what to observe during the test and acceptance criteria for each test.

If control and monitoring system/components is part of the equipment delivery, documentation shall be according to [3.1.4].

3.1.3 Pressure-containing and pressure-retaining equipment

A documentation package shall be submitted, containing as a minimum the following (as applicable):

Table 2 Pressure-containing and pressure-retaining equipment documentation

Document description	*Document content*
Functional design specification	Description of design basis/philosophy and design criteria, including (as applicable): — design principles applied — applied rules, standards and codes — description of all operative functions incorporated in the system and their technical realisation — description of all interfaces towards other systems and their technical realisation — description of all safety functions incorporated in the system — safe states if the operative system should fail, e.g. normally energised and normally de-energised circuits — requirements to the system in order to maintain an acceptable level of safety — dangerous operations and requirements to corresponding manual actions — applied loads, static and dynamic — rating with respect to power, temperature, pressure, etc. — environmental conditions — requirements to maintenance.
Assembly or arrangement drawings	A drawing showing how the parts of a mechanical assembly are arranged together
Detailed drawings	A drawing showing geometric dimensions, scantlings and arrangement of the object. The drawing shall include: — details of parts and openings — material specifications — for important components of welded construction, full details of joints, welding procedures, filler metal particulars and heat treatment after welding specification — fabrication tolerances.
Piping components specifications	A document describing for each system: — type of pipe or component (including information on gaskets/sealing) — information on safety valves (including capacity calculations, set value, etc.) — pipe or component design standard — dimensions (for pipes, outside diameter and wall thickness) — design pressure — design temperature — material specifications — allowances (e.g. corrosion, erosion) — fabrication tolerances — test pressure.

Document description	*Document content*
Material specification	A document describing: — scope, references (applied material standard) and definitions — production process, delivery condition and chemical composition requirements — mechanical testing and requirements — inspection and non-destructive testing — repair — dimensions and tolerances — surface protection — certification and marking.
Design analyses (according to design code)	A document providing: — objectives — premises — assumptions — conclusions. relating to analysis of: — static strength — dynamic strength — vibration. Equations used shall have references to relevant design codes/standards. Measurements used shall have references to relevant detail drawings.
Non-destructive testing (NDT) plan	A document describing the methods, extent and criteria for the non-destructive testing that shall be performed.
Test procedure	A document describing the test configuration and test methods for testing before delivery, specifying for each test: — initial condition — how to perform the test — what to observe during the test and acceptance criteria for each test.

If control and monitoring system/components is part of the equipment delivery, documentation shall be according to [3.1.4].

3.1.4 Control and monitoring systems

3.1.4.1 General

A documentation package shall be submitted according to DNVGL-OS-D202 Ch.3 Sec.1 [2] and DNVGL-OS-D201 Ch.3 Sec.1 [2] (as applicable).

3.1.4.2 Simulator-based testing

If software is tested by use of a simulator, a simulation test package containing the following documentation shall also be provided:

Table 3 Simulation test package documentation

Document description	*Document content*
Operation manual	A document intended for regular use on board, providing information on: — operation modes — operating instructions for normal and degraded operating modes — details of the user interface — transfer of control — redundancy — test facilities — failure detection and identification facilities, automatic and manual — data security — access restrictions — special areas requiring user attention — procedures for start-up — procedures for restoration of functions — procedures for data back-up where applicable.
Control system functional description	A document describing: — system configuration — scope of supply — what is controlled and monitored and how — safe state(s) for each function implemented — switching mechanisms for systems designed with redundancy. Additionally for hot back-up systems: — switching mechanisms for systems designed with redundancy.
List of controlled and monitored points (I/O list)	A list describing for each connected input and output device: — tag number — service description — alarm group — type of signal (analog, digital, bus communication, input, output) — set-point — range — input and output (I/O) assignment or allocation to I/O card and processing system (required for integrated systems and for redundant systems).
Test setup block diagram (topology)	A drawing showing PLCs, HMIs, network switches, simulators, communication lines and interfaces, including hardwire serial numbers.
Simulator user manual	A document describing the simulator architecture, the simulator functionalities (how to introduce failures, how to trend signals etc.) and the different graphical user interfaces (GUI).
Simulator validation test program	A document listing the validation tests to be performed, proving that the simulator functionality is adequate for the testing scope, i.e. all the modes and functions shall be included.

Document description	*Document content*
Simulator validation test report	A document including recorded results for each of the test cases as included in the simulator validation test program.
Simulator test program	A document based on the functional description and FMEA/failure mode description listing functions and failure modes to be tested specifying for each test: — initial condition (including ignored/not interfaced signals) — how to perform the test, what to observe during the test and acceptance criteria for each test.
Simulator test report	A document including recorded results for each of the test cases as included in the simulator test program. Findings identified shall be described in the report including at least the following information: — description of the finding, including an explanation of why it is a finding — recommended action or follow up — responsible party for following up corrective action — deadline for completion of the action. The document shall also include details/information about the system and simulator setup for the simulator testing, such as: — software version numbers for system under test — software version numbers for simulator used for testing.

3.1.5 Manifolds

A documentation package shall be submitted, containing as a minimum the following (as applicable):

— Documentation of support structure according to [3.1.2].
— Documentation of control and monitoring system according to [3.1.4].

Table 4 Manifold documentation

Document description	*Document content*
Functional design specification	Description of design basis/philosophy and design criteria, including (as applicable): — design principles applied — applied rules, standards and codes — description of all operative functions incorporated in the system and their technical realisation — description of all interfaces towards other systems and their technical realisation — description of all safety functions incorporated in the system — safe states if the operative system should fail, e.g. normally energised and normally de-energised circuits — requirements to the system in order to maintain an acceptable level of safety — dangerous operations and requirements to corresponding manual actions — applied loads, static and dynamic — rating with respect to power, temperature, pressure, etc. — environmental conditions — requirements to maintenance.

Document description	*Document content*
Piping and Instrumentation diagrams (P&ID)	A diagrammatic drawing including the following: — components including reference identification (tag numbers) — size of pressure vessels and piping — piping with line numbers — pump type and capacity — type of valves and connections — type of expansion elements — location of shutdown and isolation valves — failure mode of control and shutdown and isolation valves — hydrostatic test pressure after installation on board — instrumentation, including safety devices, control and monitoring equipment — signal lines, sufficient to describe the function — heat-tracing cables and insulation for pipelines, valves, instruments, vessels, etc. — maximum differential pressure across centrifugal pumps — maximum flow through pumps and compressors — set points for all shutdown and isolation valves and rupture disks — design and operational data for the components — input and output signals from safety systems.
Assembly or arrangement drawings	A drawing showing how the parts of a mechanical assembly are arranged together (Allowable nozzle loads shall be stated on general arrangement drawings, see Ch.2 Sec.3 [2.2.5])
Isometric drawings	A 3D drawing showing how the parts of a mechanical assembly are arranged together
Detailed drawings	A drawing showing geometric dimensions, scantlings and arrangement of the object. The drawing shall include: — details of parts and openings — material specifications — for important components of welded construction, full details of joints, welding procedures, filler metal particulars and heat treatment after welding specification — fabrication tolerances.
Piping components specifications	A document describing for each system: — type of pipe or component — pipe or component design standard — dimensions (for pipes, outside diameter and wall thickness) — design pressure — design temperature — material specifications — allowances (e.g. corrosion, erosion) — fabrication tolerances — test pressure.

Document description	*Document content*
Material specification	A document describing: — scope, references (applied material standard) and definitions — production process, delivery condition and chemical composition requirements — mechanical testing and requirements — inspection and non-destructive testing — repair — dimensions and tolerances — surface protection — certification and marking.
Design analyses (including wall thickness calculations, pipe stress and flexibility analysis with stress iso's (see [1.4], etc.)	A document providing: — objectives — premises — assumptions — conclusions. relating to analysis of: — static strength — dynamic strength — vibration. Equations used shall have references to relevant design codes/standards. Measurements used shall have references to relevant detail drawings.
Non-destructive testing (NDT) plan	A document describing the methods, extent and criteria for the non-destructive testing that shall be performed.
Test procedure	A document describing the test configuration and test methods for testing before delivery, specifying for each test: — initial condition — how to perform the test — what to observe during the test and acceptance criteria for each test.

3.2 Material certificates

3.2.1 General

Materials for special area, primary structural members/mechanical components, pressure-containing and pressure-retaining components shall be supplied with documentation stating:

— process of manufacture and heat treatment
— results for relevant properties obtained through appropriate tests carried out on product/batch in accordance with recognised standards.

Certificates shall be 3.1 certificate according to ISO 10474, or equivalent.

3.2.2 Bolts

Bolts for special area, primary structural members/mechanical components, pressure-containing and pressure-retaining components shall be certified according to Table 5.

Table 5 Certification requirements for bolts

Category	*Load condition*	*Type of certificate[1)]*
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)].	2.2 certificate
B[3) 4)]	Bolts exposed to external loading and custom designed bolts (e.g. riser bolts, bonnet bolts, derrick foundation bolts, man-riding equipment, etc.) and non-redundant applications.	3.1 certificate

1) According to ISO 10474.
2) Bolts and bolt groups shall be evaluated for redundancy. The evaluation shall take into account progressive collapse and the associated redistribution of reaction forces and moments. If such evaluation is not documented, the bolts shall be delivered with minimum 3.1 certificates.
3) Bolts, which are to be delivered with 3.1 certificates, shall be clearly identified on the general arrangement or assembly drawings.
4) MT shall be carried out for custom designed bolts as per Ch.2 Sec.8 [3.1.1.7].

SECTION 3 SYSTEM AND EQUIPMENT CERTIFICATION

1 General

1.1 Certification principles

1.1.1 For general DNV GL certification procedures and requirements, see Sec.1 [2.1.1].

1.1.2 DNV GL uses categorization in order to clearly identify the certification and approval requirements for various systems and equipment.

Categorization of systems and equipment depends on their role as a barrier or barrier element. Systems and equipment providing essential, important or safety functions will normally be categorized as category I. Other systems and equipment will normally be categorized as category II. Once assigned, the category defines the scope of activities required for DNV GL certification and classification.

Guidance note:

Some systems or equipment providing essential, important or safety functions might be categorized as category II. This might be due to the simplicity of the system/equipment, the quality of normative codes and standards or the production methods.

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1.1.3 System and equipment categorisation shall be as follows:

I = systems/equipment where a DNV GL product certificate is required.

II = systems/equipment where a Works certificate prepared by the manufacturer is required.

1.1.4 Certification category I

For certification category I, the following procedure shall be followed:

— design approval, documented by a design verification report (DVR) or type approval certificate (TA)

  Specific requirements for design approval:

  — review of design documentation required to conform with applicable standards e.g. drawings, calculations, materials specifications, system design specifications and FMEA reports, as applicable.
  — witness of design qualification/validation testing, and review of design validation reports.

  Guidance note:

  Witness of design qualification/validation testing may be included in the scope of manufacturing survey.

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— manufacturing survey, documented by issue of a product certificate.

  Specific requirements for manufacturing survey (as applicable):

  — pre-production meeting, prior to the start of manufacturing (including review of ITP and clarification of DNV GL involvement)
  — survey during manufacturing
  — review of manufacturing records
  — witness testing (see Ch.2 Sec.8 [4.1]).

  Guidance note:

  An internal test according to the test program should be performed by the test responsible prior to test witnessed by DNV GL.

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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 (as applicable)
— type of manufacturing methods.

1.1.5 Certification category II

Systems and equipment of certification category II are normally accepted based on a works certificate prepared by the manufacturer. The certificate shall contain the following, as a minimum:

— equipment specification or data sheet
— operating limitations
— statement from the manufacturer, confirming that the equipment has been designed, manufactured and tested according to recognised methods, codes and standards.

Guidance note:

E.g. references provided in Ch.1 Sec.1 [3] or Ch.1 Sec.1 [4].

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— test records (as applicable).

Guidance note:

Certificate of Compliance is also acceptable, provided it contains the information required.

Compliance to the technical requirements of this standard is not mandatory for certification category II.

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1.1.6 Categorization of systems and equipment is provided in Table 1 to Table 17.

1.1.7 Categorization of electrical equipment is not provided, as all electrical equipment necessary for operation of components in category I systems/equipment shall be certified if certification of such equipment is required by DNVGL-OS-D201.

Guidance note:

This includes motors, transformers, converters, etc.

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1.1.8 For systems or equipment not defined in the following tables, categorization will be decided on a case by case basis.

1.1.9 Replacement parts shall be certified in accordance with the requirements of the parts it will be replacing.

1.2 System and equipment categorisation

Table 1 Drilling related structures

	Material or equipment	*DNV GL certification categories*	
		I	*II*
Drilling structures	Derrick and other drilling tower designs	X	
	Other design	X	

	Material or equipment	DNV GL certification categories	
		I	II
Miscellaneous	Skids, spreader beams and lifting lugs/brackets used for regular lifting[1)]	X	
Bolting	Custom designed bolting	X	
1) Loose lifting lugs/brackets may be accepted with other proper certification.			

Table 2 Hoisting and rotating systems

	Material or equipment	DNV GL certification categories	
		I	II
Conventional hoisting system	Sheaves	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	
	Sheaves	X	
	Sheave clusters including support beams	X	
	Guide track and dolly	X	
	Equalizers	X	
	Deadline anchor	X	
	Valves controlling load	X	
	Other valves[1)]	X	
	Flexible hoses[1)]	X	
Rack and pinion hoisting system	Rack	X	
	Pinion	X	
	Gear transmissions and brakes	X	
	Push/pull unit (travelling assembly)	X	
	Guide track and dolly	X	
	Equalizers	X	
	Other equipment transferring braking loads	X	

	Material or equipment	*DNV GL certification categories*	
		I	*II*
Hoisting equipment in derrick	Drilling hook 2)	X	
	Swivel 2)	X	
	Top drive wash pipe/mud pipe1)	X	
	Links	X	
	Spiders	X	
	Elevators	X	
	Elevator bushing/insert		X
	Drilling line and sand line		X
	Cranes in derrick	X	
	Lift/tension frames	X	
Rotating equipment	Rotary table including skid adaptor and driving unit	X	
	Topdrive including pipehandler2)	X	
	Master bushing		X

1) Requirements to individual piping components, see Table 15.
2) Other types of equipment having similar function as the ones listed above are to be equally categorised.

Table 3 Heave compensation and tensioning systems

	Material or equipment	*DNV GL certification categories*	
		I	*II*
General	Hydraulic cylinders and other pressure vessels 1)	X	
	Pipes, fittings and valves2)	X	
	Flexible hoses	X	
	Hydro-pneumatic accumulators	X	
	Air compressors and air dryers		X
	Wire ropes		X
	Sheaves	X	
	Anti-recoil valve	X	
	Safety valves3)	X	
Heave compensation	Heave compensator system assembly	X	
	Primary structural/mechanical components in compensator system	X	
	Deadline compensator	X	

	Material or equipment	DNV GL certification categories	
		I	II
Tensioning systems	Riser tensioner system assembly	X	
	Top tension/conductor tensioner system assembly	X	
	Primary structural/mechanical components in tension system	X	
	Guidelines and podline tensioners/tension winches	X	
	Tension frames	X	
	Telescopic arms for tension lines	X	
	Support for flexible control hoses (e.g. banana sheaves, power saddles)	X	
	Air control skid with manifold[2)]	X	
	Swivels and goosenecks on tension cylinders [2)]	X	

1) See Table 16.
2) Requirements to individual piping components, see Table 15.
3) Design review of bursting disc is not required. The extent of witnessing of leak-, calibration-, capacity- and qualification testing to be agreed with DNV GL based on manufacturers QA/QC system.

Table 4 Handling Systems

	Material or equipment	DNV GL certification categories	
		I	II
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 including gripper yokes	X	
	Slewing rings[2)]	X	
	Finger board including belly board	X	
	Mousehole[3)]	X	
	Riser Spider and Gimbal	X	
	Riser Handling and Running Tools	X	
BOP and Xmas tree handling[4)]	BOP/XT crane, carrier, guide frame, sea fastening, etc.	X	
	Sheaves and sheave blocks	X	
	Tripsaver skid/trolley	X	

	Material or equipment	*DNV GL certification categories*	
		I	*II*
	Skids or carriers for handling of equipment at height or over moon pool	X	
	Other skids		X
Miscellaneous	Power tongs for pipe handling or iron roughneck		X
	Kelly spinner		X
	Power slips		X

1) Accepted as cat. II given the following conditions are met:

- 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.

If the equipment accepted as cat.II is placed on a substructure raising it up from the deck, the substructure is considered cat.I.

2) Accepted as cat. II if not part of load path.

3) Accepted as cat. II if not powered.

4) For auxiliary winches, see Table 6.

Table 5 Man-riding equipment

	Equipment	*DNV GL certification categories*	
		I	*II*
Man riding equipment	Man riding winches, access boards, baskets, etc.	X	
	Slewing rings[1)]	X	

1) Accepted as cat. II if not part of load path.

Table 6 Other systems

	Equipment	*DNV GL certification categories*	
		I	*II*
Winches[1)]	Winches for lifting purposes	X	
	Winches for non-lifting purposes		X
Miscellaneous	Hydraulic power units including pumps and manifolds[2)]		X
	Skids or carriers for handling of equipment at height or over moon pool	X	
	Rails for cranes, skids and other equipment		X

	Equipment	DNV GL certification categories	
		I	*II*
	Slewing rings[3], gear transmissions and brakes for lifting appliances or other safety or essential functions	X	

1) Sheaves and blocks may be accepted with other proper certification.
2) Excluding equipment/components related to control functions, which shall be certified in accordance with Table 17.
3) Accepted as cat. II if not part of load path.

Table 7 Bulk and mixing systems

	Equipment	*DNV GL certification categories*	
		I	*II*
Bulk storage	Pressurised storage tanks [1]	X	
	Piping for pressurised bulk transport		X
	Safety valves[2]	X	
	Pumps for bulk transport		X
Drilling fluid mixing	Piping for mixing of drilling fluid		X
	Centrifugal pumps for mixing / transfer of drilling fluid		X
	Drilling fluid tanks		X
	Chemical mixers		X
	Agitators for drilling fluid		X

1) See Table 16.
2) Design review of bursting disc is not required. The extent of witnessing of leak-, calibration-, capacity- and qualification testing to be agreed with DNV GL based on manufacturers QA/QC system.

Table 8 Drilling fluid circulation and cementing systems

	Equipment	*DNV GL certification categories*	
		I	*II*
Drilling fluid circulation	Drilling fluid pump – high pressure side	X	
	Mud manifold / standpipe manifold (except valves) [2]	X	
	Valves in mud manifold and in high pressure piping	X	
	Pulsation dampers	X	
	Circulation head piping including drilling fluid pump discharge [2]	X	
	Mud hoses	X	
	Safety valves[3]	X	

	Equipment	*DNV GL certification categories*	
		I	*II*
	Piping for suction line to drilling fluid pump		X
	Rotary hose assembly	X	
	Top drive mud pipe	X	
	Drill string		X
	Mud return pipe		X
	System for automatic mud sampling	X	
	Shale shaker		X
	Drilling fluid tanks		X
	Degasser including piping to burners or to vents 1)2)	X	
Cementing	Cement pump – high pressure side	X	
	Cementing head	X	
	Cement manifold / standpipe manifold (except valves) 2)	X	
	Valves in cement manifold and in high pressure piping	X	
	Pulsation dampers	X	
	Circulation head piping including cement pump discharge 2)	X	
	Cement hoses	X	
	Safety valves3)	X	
	Centrifugal pumps for cement mixing / transfer of cement slurry		X
	Piping for mixing of cement, and suction line to cement pump		X

1) See Table 16.

2) System certification shall cover design, manufacture and testing of assembly. Requirements to individual piping components, see Table 15.

3) Design review of bursting disc is not required. The extent of witnessing of leak-, calibration-, capacity- and qualification testing to be agreed with DNV GL based on manufacturers QA/QC system.

Table 9 Managed Pressure Drilling (MPD) systems

	Equipment	*DNV GL certification categories*	
		I	*II*
General	Accumulators1)	X	
	Manifolds2)	X	
	Flexible hoses2)	X	
	Pipes, fittings and valves2)	X	

	Equipment	DNV GL certification categories	
		I	*II*
	Safety valves[3)]	X	
	Control pods[4)]	X	
	Mud return line	X	
	LARS (Launch and Recovery systems)	X	
	Measuring devices/sensors		X
	MPD choke manifold	X	
	Back-pressure pump		X
	- fluid end	X	
	- pulsation dampener	X	
	Subsea pump	X	
	Non-return valves/restriction valves in drill string		X
	Annular preventer	X	
	Rotating Control Device	X	
	Non-rotating Control Device	X	
	Annular preventer or other equipment used to isolate well pressures	X	
	Riser sections including joints	X	

1) See Table 16.

2) Manifolds, piping components and flexible hoses in the following lines are to be considered cat.I:

— bleed off line from RCD
— mud return line from flowspool to, and including, MPD choke manifold
— relief lines
— connections to choke & kill system (at least two valves closest to C&K system)
— connections to high pressure mud and cement system (at least two valves closest to high pressure mud and cement system).

System certification shall cover design, manufacture and testing of assembly. Requirements to other individual piping components, see Table 15.

3) Design review of bursting disc is not required. The extent of witnessing of leak-, calibration-, capacity- and qualification testing to be agreed with DNV GL based on manufacturers QA/QC system.

4) Control pod is subject to certification as part of the MPD control system, see Table 17.

Table 10 BOP systems

	Equipment	DNV GL certification categories	
		I	*II*
Blowout prevention equipment	Blowout preventer stack assembly	X	
	- Connectors for wellhead and riser	X	
	- Ram preventers	X	
	- Ram blocks	X	
	- Annular preventers	X	
	- Accumulators for subsea stack	X	
	- Valves in choke and kill lines	X	
	- Gas bleed valves and booster valves	X	
	- Drilling spools / spacer spools	X	
	- Clamp	X	
	- BOP frame and working platforms	X	
	Test Mandrel		X
	Test stump	X	
	BOP test pump		X
	Valves in drillstring	X	
Blowout prevention, control equipment	Accumulators in control system	X	
	Pipes, fittings and valves[1)]	X	
	Flexible control hoses/umbilicals/cables		X
	Hydraulic conduit hoses	X	
	Control system components part of hydraulic hose reel	X	
	Hydraulic hose reel [2)]		X
	Control pods [3)]	X	
	Support for flexible control hoses (e.g. banana sheaves, power saddles)	X	
	Acoustic BOP control equipment	X	

1) Requirements to individual piping components, see Table 15. Pipes, fittings and valves may be certified in batch, or as part of system/equipment.
2) The reel itself (equipment not related to BOP control functions).
3) Control pod is subject to certification as part of the BOP control system, see Table 17.

Table 11 Diverter systems

	Equipment	DNV GL certification categories	
		I	*II*
Diverter unit, equipment and control equipment	Diverter house with annular valve	X	
	Diverter pipes, fittings and valves[1)]	X	
	Diverter handling tool	X	

1) Requirements to individual piping components, see Table 15. Pipes, fittings and valves may be certified in batch, or as part of system/equipment.

Table 12 Choke & kill systems

	Equipment	DNV GL certification categories	
		I	*II*
Choke and kill, equipment and control equipment	Choke and kill manifold	X	
	- Pipes, fittings and valves in choke and kill manifold [1)]	X	
	Pipes, fittings and valves to and from choke and kill manifold (including choke, kill, and booster lines)[1)]	X	
	Flexible hoses for choke, kill and booster lines	X	
	Mud/gas separator	X	
	Swivel joints	X	
	Emergency circulation pump – pressure side	X	
	Clamps for hoses		X

1) Requirements to individual piping components, see Table 15. Pipes, fittings and valves may be certified in batch, or as part of system/equipment.

Table 13 Drilling riser systems

	Equipment	DNV GL certification categories	
		I	*II*
Marine riser, equipment and control equipment	Ball joint and flexible joint	X	
	Riser sections including joints	X	
	Booster valves	X	
	Support ring for riser tensioning	X	
	Telescopic joint	X	
	Accumulators	X	

Table 14 Well test systems

	Equipment	*DNV GL certification categories*	
		I	*II*
Well test systems	Surface flow tree, including valves	X	
	Pipes and fittings, including swivels [1)]	X	
	Valves	X	
	Flexible hoses	X	
	Pressure vessels and separators [2)]	X	
	High pressure pumps – high pressure side	X	
	Other pumps		X
	Burners	X	
	Flare booms	X	
	Safety valves[3)]	X	

1) System certification shall cover design, manufacture and testing of assembly. Requirements to individual piping components, see Table 15.

2) See Table 16.

3) Design review of bursting disc is not required. The extent of witnessing of leak-, calibration-, capacity- and qualification testing to be agreed with DNV GL based on manufacturers QA/QC system.

Table 15 Piping components[1) 2) 3)]

Component type	*Standard*	*High pressure*	*Safety/Essential/ Important function*	*DNV GL certification categories*	
				I	*II*
Type A	Yes	N/A	N/A		X
Type B	No	Yes	Yes/No	X	
Type C	No	Yes/No	Yes	X	
Type D	No	No	No		X

1) Only applicable for systems/equipment which have a specific reference to this table.
2) Guidance on use of table:

- Component type: Component to be evaluated for categorization.
- Standard: a component designed and manufactured in accordance with one of the following standards (with applicable requirements for both dimensions and materials):

Component	*Standard*	
Flange	API Spec 6A	Wellhead and Christmas Tree Equipment
	ASME B16.5	Pipe Flanges and Flanged Fittings
	ASME B16.36	Orifice flanges
	ISO 6162	Hydraulic fluid power - Flange connections with split or one-piece flange clamps and metric or inch screws
	ISO 6164	Hydraulic fluid power - Four-screw, one-piece square-flange connections for use at pressures of 25 MPa and 40 MPa (250 bar and 400 bar)
	EN 1092	Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 1: Steel flanges
Hub/clamp connection	API Spec 16A	Drill Through Equipment
Pipe	ASME B31.3	Process Piping
Block	API Spec 6A	Wellhead and Christmas Tree Equipment

Example 1: A flange designed and manufactured in accordance with API Spec 6A - PSL3 is a Type A component and can be considered cat.II.

- High pressure: a component rated above 3000 psi.
- Safety/Essential/Important function: see Ch.2 Sec.5, Ch.2 Sec.6 and Ch.2 Sec.7.

Example 2: A valve designed and manufactured in accordance with an in-house standard and rated at 3000 psi, but part of an essential function, is a Type C component, hence cat.I.

3) Pipes and fittings are normally to be certified in batch. Pipes and fittings might be documented by survey statement(s).

Table 16 Pressurized equipment

	Equipment	*DNV GL certification categories*	
		I	*II*
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 × 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 17 Control and monitoring systems

	Equipment	*DNV GL certification categories*	
		I	*II*
Control systems	Well influx management system (WIM)	X	
	Well shut-in and disconnect system (WSD)	X	
	Blowout prevention (BOP)	X	
	Diverter	X	
	Choke and Kill	X	
	Emergency transfer/circulation	X	
	Heave compensating	X	
	Drilling hoisting system	X	
	Riser tension	X	
	MPD control system	X	
	Well test system	X	
	Other safety systems[1)]	X	
	Other essential/important systems	X	
1) E.g. pressure relief systems.			

2 Manufacturing records

2.1 General

2.1.1 Manufacturing records shall be maintained by the manufacturer in a traceable manner, so that relevant information regarding design specifications, materials, manufacturing processes, inspection, heat treatment, testing, etc. (as applicable) is available upon request.

2.1.2 Manufacturing record for category I systems/equipment shall as a minimum include the following (as applicable):

— manufacturer's statement of compliance
— reference to design specifications and drawings
— material traceability for manufactured product with reference to respective material certificates
— welding procedure specifications and qualification test records
— weld traceability for manufactured product with reference to the applied welding procedure
— heat treatment records
— non-destructive testing (NDT) reports indicating method, extent, acceptance criteria, and results
— load, pressure and functional test reports
— as-built part numbers and revisions.

3 Final deliverables

3.1 Before system/equipment delivery

3.1.1 The following documentation will normally be issued by DNV GL for category I systems and equipment:

a) Design verification report (DVR)

  — DVR will be issued by the design approval responsible for each category I system/equipment, unless covered by a valid type approval certificate (TA).

  DVRs shall contain all information needed to be followed up by the surveyor attending manufacturing survey and installation of the equipment, and as a minimum include:

  — design codes and standards used as basis for design verification
  — design limitations (e.g. temperature, pressure, SWL, etc.)
  — follow-up comments related to e.g. testing, manufacturing and installation of the system or equipment.

b) Product certificate (PC)

  — PC shall be issued for all category I systems and equipment (including control systems)
  — PC will be issued upon successful completion of design verification and manufacturing follow-up (including review of documentation, testing before delivery, etc.). PC cannot be issued if non-conformances are outstanding (e.g. missing design verification).

3.1.2 The following documentation might be issued by DNV GL for systems and equipment subjected to certification, if found necessary:

Report for incomplete certification (RIC:

— RIC shall only be issued if the system/equipment is delivered prior to issuance of final product certificate (PC). Since PC cannot be issued if there are non-conformances to the system or equipment, an RIC shall be used, containing detailed description of the non-conformances. RIC shall always be replaced by a PC when all non-conformances are closed.

3.2 After installation and testing onboard

3.2.1 The following documentation will normally be issued by DNV GL for category I systems and equipment:

Survey statement

- Survey statements shall be issued for all category I systems and equipment (including control systems) upon satisfactory installation, survey and onboard testing (commissioning and integration tests). The survey statement shall contain clear references to all DVRs/TAs and PCs for systems/equipment covered by the survey statement, and shall include references to all activities performed (e.g. testing, surveys, etc.).

APPENDIX A WORKOVER AND WELL INTERVENTION FACILITIES

1 Introduction

1.1 General

1.1.1 This appendix contains criteria, technical requirements and guidance on design, manufacturing, installation and testing of workover and well intervention facilities.

1.1.2 The appendix is based on the requirements of the standard, which is a facilities standard and is supplementary to other discipline specific standards.

Guidance note:

E.g. for structures, electrical, materials, etc., as specified in Ch.1 Sec.1 [3].

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1.2 Objectives

The objectives of this appendix are to:

- provide an internationally acceptable standard of safety and reliability for workover and well intervention facilities, by defining minimum requirements for design, manufacturing, installation and testing of such facilities
- serve as a reference document in contractual matters
- serve as a guideline for designers, manufacturers, purchasers, owners, contractors and operators
- specify requirements for workover and well intervention facilities subject to DNV GL certification and classification.

1.3 Scope and application

1.3.1 Workover and well intervention facilities shall follow the requirements and principles provided in the standard.

However, only parts of Ch.2 Sec.5, Ch.2 Sec.6 and Ch.2 Sec.7 which are referred to in this appendix shall apply.

1.3.2 The appendix has been written for general world-wide application.

Guidance note 1:

Governmental regulations might include requirements in excess of the provisions of this appendix.

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Guidance note 2:

For cold climate operations, see DNVGL-OS-A201.

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1.3.3 The appendix has been written for workover and well intervention facilities located on mobile offshore drilling units (MODUs) and on offshore installations (OIs) of various types.

Guidance note:

The appendix should be applied from concept design, manufacturing, through to final installation and testing, including major modifications.

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1.3.4 The appendix covers workover and well intervention systems and equipment located both surface and subsea, including connectors, but not wellhead/christmas tree or elements located below wellhead/christmas tree.

1.3.5 Requirements provided by this appendix apply to all systems and equipment, whether permanently or temporarily installed.

Guidance note:

See DNV-OTG-05 for guidance on temporarily installed equipment.

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1.3.6 Requirements presented are minimum requirements to be satisfied, and available technological and technical improvements at the time of application should be taken into account.

The prescriptive requirements in the appendix are results of hazard identification and barrier analysis based on existing technology and operations, and are not intended to inhibit the development and application of new technology.

Where the identified hazards and the prescriptive requirements provided might not be suitable or complete, additional hazard identification shall be performed and safeguards implemented accordingly.

1.3.7 Introduction of novel technology or designs shall be preceded by a recognised qualification process.

Guidance note:

E.g. as described in DNVGL-RP-A203.

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1.3.8 Alternative solutions, if clearly proven to provide an equivalent or higher safety level than required, may be considered to comply with this appendix.

1.4 Deviation from the requirements

Any modifications, deviations or exceptions to the requirements of this appendix shall be documented and agreed between all contracting parties.

1.5 Definitions and abbreviations

See Ch.1 Sec.1 [2].

1.6 Normative references

ISO 13628-7 and applicable references in Ch.1 Sec.1 [3].

1.7 Informative references

See Ch.1 Sec.1 [4].

2 Design principles

See applicable parts of Ch.2 Sec.1.

3 Materials

See applicable parts of Ch.2 Sec.2.

4 Piping

See applicable parts of Ch.2 Sec.3.

5 Electrical, instrumentation, control and monitoring systems

See applicable parts of Ch.2 Sec.4.

6 General requirements for workover and well intervention systems

See applicable parts of Ch.2 Sec.5.

7 Hoisting, rotating and handling systems

7.1 Workover and well intervention related structures

See applicable parts of Ch.2 Sec.6 [1].

7.2 Hoisting and rotating systems

See applicable parts of Ch.2 Sec.6 [2].

7.3 Heave compensation and tensioning systems

See applicable parts of Ch.2 Sec.6 [3].

7.4 Handling systems

See applicable parts of Ch.2 Sec.6 [4].

7.5 Man-riding equipment

See applicable parts of Ch.2 Sec.6 [5].

7.6 Other systems

See applicable parts of Ch.2 Sec.6 [6].

8 Well pressure and flow control systems

8.1 Introduction

See applicable parts of Ch.2 Sec.7 [1].

8.2 Bulk and mixing systems

See applicable parts of Ch.2 Sec.7 [2].

8.3 Well influx prevention - fluid circulation, well stimulation and cementing systems

See applicable parts of Ch.2 Sec.7 [3].

8.4 Blowout prevention systems

8.4.1 General

8.4.1.1 Blowout prevention systems normally comprise the following:

Riserless systems:

— pressure control head (including stuffing box, grease injection)
— grease injection
— lubricator section
— blowout prevention section (EDP, LRP).

Workover riser in open sea systems:

— surface flow tree
— riser system
— blowout prevention section (EDP, LRP).

Workover riser, marine riser and drilling BOP systems:

— drilling well control system (see Ch.2 Sec.7 [4])
— surface flow tree
— workover riser or landing string (run through marine riser system)
— subsea test tree (run inside BOP).

8.4.1.2 Blowout prevention systems are categorized as safety systems.

Guidance note:

For requirements to safety systems, see Ch.2 Sec.1 [3.4].

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8.4.1.3 No single failure shall lead to an overall system failure or loss of well control.

8.4.1.4 Well intervention blowout preventers shall in general consist of the following as a minimum:

— EDP
— LRP
— XT connector
— control and monitoring system.

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. XT)
— one shear ram in bores used for coiled tubing or wire line.

For requirements to drilling BOPs, see Ch.2 Sec.7 [4].

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8.4.1.5 Design of well intervention riser systems and components shall be in accordance with Ch.2 Sec.5 [6].

Guidance note:

E.g. ISO 13628-7 for mechanical components, unless covered by applied code or standard.

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8.4.2 Blowout preventer stacks (EDP/LRP)

8.4.2.1 The blowout preventer stack (EDP, LRP) shall as a minimum be designed to withstand the maximum differential pressure it will be exposed to in operation.

8.4.2.2 The blowout preventer stack (EDP, LRP) shall be designed to enable fluids to be conducted out of the system, and to enable fluids to be pumped into the system.

8.4.2.3 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 safe state shall be to close. The valves shall be located so that they are protected against damage from falling objects.

8.4.2.4 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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8.4.2.5 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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8.4.2.6 Valves and rams shall be able to open and close at maximum pressure and maximum flow.

8.4.2.7 The blowout preventer section body shall be designed for maximum operational loads, such as tension, bending moments, internal and external pressures and environmental loads.

8.4.2.8 Shear or blind rams and pipe rams shall be equipped with mechanical locking devices.

8.4.2.9 Flexible lines shall be in accordance with Ch.2 Sec.3 [3.3] or ISO 13628-7.

8.4.3 Riser and christmas tree connector

8.4.3.1 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.

8.4.3.2 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.

8.4.3.3 The maximum tilt angle of riser (EDP or LMRP) connector for mechanical freeing shall be stated.

8.4.3.4 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.

8.4.4 Control and monitoring

8.4.4.1 The workover and well intervention control system shall be provided with at least two 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 preventers for floating MODUs/OIs, the following additional controls shall be included:

— operational disconnect of riser connector (EDP or LMRP)
— emergency disconnect sequence.

8.4.4.2 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.

8.4.4.3 For electrical or computer based subsea systems, activation of the emergency disconnect shall initiate and complete disconnection in the correct sequence.

8.4.4.4 Design of emergency disconnect system shall take into account the required total time to execute the sequence.

8.4.4.5 One control panel shall be located at the main control station for workover and well intervention operations.

8.4.4.6 A second control panel shall be located at a suitable distance from the main control station, and shall be arranged for easy access.

8.4.4.7 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.

8.4.4.8 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.

8.4.4.9 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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8.4.4.10 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.

8.4.4.11 For electrical or computer based systems, two independent systems shall be installed. This independence shall include all design events.

8.4.4.12 The closing unit accumulators shall as a minimum meet the capacity requirements of ISO 13628-7 Sec. 5.5.7 or equivalent.

8.4.4.13 When subsea BOP/LRP systems are fitted with a secondary control system in the event of failure of main control system during an uncontrolled well situation, the following shall apply:

— it shall be possible to activate the system from a portable unit
— the secondary control system shall be independent of the main control 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.

8.4.4.14 When installed, the secondary control 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.

8.4.4.15 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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8.4.4.16 To prevent inadvertent operation, activation of all functions shall be arranged as required in Ch.2 Sec.4 [3.1].

Additionally, for floating MODUs/OIs, 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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8.4.4.17 Electro-hydraulic and multiplex (MUX) EDP/LRP systems shall be provided with two independent pods.

8.4.4.18 As long as redundancy is maintained within the umbilical and the system is fail-safe-close, only one umbilical is required.

8.5 Well influx relief - diverter systems

See applicable parts of Ch.2 Sec.7 [5].

8.6 Well normalising - choke and kill systems

8.6.1 See applicable parts of Ch.2 Sec.7 [6].

Guidance note:

Deviations from some of these referenced requirements might be accepted on a case-by-case basis for choke and kill systems covered by this appendix, if it can be proven that the required safety level is ensured by the provided functionality.

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8.6.2 If the riser annulus line is intended to be used for killing operations, it shall be sized accordingly.

Guidance note:

I.e. pump rate and pressure.

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8.7 Workover riser systems

8.7.1 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*.

8.7.2 Workover risers shall be designed to withstand applicable combined design loads relevant for their application.

Guidance note:

Relevant loads to evaluate include:

— riser tensional loads and load variations
— vessel motion
— circulation fluid specific gravity (SG)
— handling loads
— wind
— well shut-in pressures (for high pressure risers where relevant)
— collapse pressure
— waves
— current.

See ISO 13628-7, DNVGL-OS-F201 or equivalent for further guidance.

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8.7.3 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 tensioning system failure.

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8.8 Well test systems

See applicable parts of Ch.2 Sec.7 [8].

9 Manufacturing, workmanship and testing

See applicable parts of Ch.2 Sec.8.

10 Certification and classification

10.1 Introduction

Certification and classification shall follow the principles provided in Ch.3 Sec.1.

MODUs/OIs fitted with drilling facilities that have been designed, manufactured, installed and tested in accordance with the requirements of this appendix, under supervision of DNV GL, will be entitled to the class notation **WELL**.

Guidance note:

For further details on class scope, see DNVGL-RU-OU-0101. See DNVGL-SI-0166 for **WELL(N)**.

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10.2 Documentation requirements

See applicable parts of Ch.3 Sec.2.

10.3 System and equipment certification

Categorization of workover and well intervention systems and equipment is provided in Table 1.

For categorization of systems and equipment not covered byTable 1, but described in this appendix, see Ch.3 Sec.3.

Table 1 Workover and well intervention systems

	Material or equipment	*DNV GL certification 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	
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	

	Material or equipment	*DNV GL certification categories*	
		I	*II*
	Workover control system	X	
	Umbilicals for subsea controls		X
1) See Ch.3 Sec.3 Table 10.			

CHANGES – HISTORIC

July 2015 edition

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

— Sec.5 [3.2.2]: First item moved to separate clause Sec.5 [3.5.2].
— Sec.5 [6.4]: Moved item 3, including Guidance note, to Sec.5 [3.2.1] item 10.
— Sec.5 [7.3.8]: Updated guidance note. Removal of first paragraph, second sentence since this is covered by rule requirement Sec.5 [7.3.6] item 2.

• Ch.3 Sec.3 System and equipment certification

— Sec.2 [1.1]: Removed "or other recognized standards" in second sentence.
— Sec.3 Table 6: Detailing certification requirements for standpipe manifold and cement.