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OFFSHORE STANDARD  
DNV-OS-E201

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HYDROCARBON PRODUCTION PLANT

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OCTOBER 2000

DET NORSKE VERITAS

# FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

DNV Offshore Codes consist of a three level hierarchy of documents:

- *Offshore Service Specifications*. Provide principles and procedures of DNV classification, certification, verification and consultancy services.
- *Offshore Standards*. Provide technical provisions and acceptance criteria for general use by the offshore industry as well as the technical basis for DNV offshore services.
- *Recommended Practices*. Provide proven technology and sound engineering practice as well as guidance for the higher level Offshore Service Specifications and Offshore Standards.

DNV Offshore Codes are offered within the following areas:

- A) Qualification, Quality and Safety Methodology
- B) Materials Technology
- C) Structures
- D) Systems
- E) Special Facilities
- F) Pipelines and Risers
- G) Asset Operation

## Amendments April 2002

This Code has been amended, but not reprinted in April 2002. The changes are incorporated in the Web, CD and printable (pdf) versions. The amendments are shown in red colour in the Web and CD versions.

All changes affecting DNV Offshore Codes that have not been reprinted, are published separately in the current *Amendments and Corrections*, issued as a printable (pdf) file.

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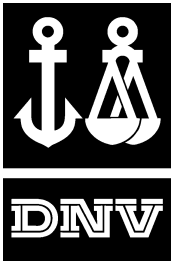
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HYDROCARBON PRODUCTION PLANT

CHAPTER 1

**INTRODUCTION**

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## SECTION 1 INTRODUCTION

### A. General

#### A 100 Introduction

**101** This offshore standard contains criteria, technical requirements and guidance on design, construction and commissioning of offshore hydrocarbon production plants and associated equipment.

**102** The standard is applicable to plants located on floating offshore units and on fixed offshore structures of various types.

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

#### A 200 Objectives

**201** The objectives of this standard are to:

- provide an internationally acceptable standard of safety for hydrocarbon production plants by defining minimum requirements for the design, materials, construction and commissioning of such plant
- serve as contractual a reference document between suppliers and purchasers
- serve as a guideline for designers, suppliers, purchasers and contractors
- specify procedures and requirements for hydrocarbon production plants subject to DNV certification and classification.

#### A 300 Organisation of this standard

**301** This standard is divided into three main chapters:

*Chapter 1:* General information, scope, definitions and references.

*Chapter 2:* Technical provisions for hydrocarbon production plants for general application.

*Chapter 3:* Specific procedures and requirements applicable for certification and classification of plants in accordance with this standard.

#### A 400 Scope and application

**401** The standard covers the following systems and arrangements, including relevant equipment and structures:

- production and export riser systems
- well control system
- riser compensating and tensioning system
- hydrocarbon processing system
- relief and flare system
- production plant safety systems
- production plant utility systems
- water injection system
- gas injection system
- storage system
- crude offloading system.

**402** The following are considered as main boundaries of the production plant, as relevant:

- lower riser connection to sea floor system
- control system connection to sea floor system
- connection to production buoy
- shutdown valve at crude outlet from production plant to crude storage or loading buoy.

#### A 500 Assumptions

**501** The requirements apply to the production plant as such, and presuppose that systems and arrangements as listed below are provided on the unit or installation:

- safe escape
- adequate separation between hydrocarbon processing plant, utility area, accommodation
- fire and explosion safety
- emergency shutdown
- alarm and intercommunication
- utility systems.

**502** It is assumed that the subsea production system to which the unit or installation is connected, is equipped with sufficient safe closure barriers to avoid hazards in case of accidental drift-off of the unit or dropped objects from the unit or installation.

### B. Normative References

#### B 100 General

**101** This standard includes references to some recognised codes and standards which are frequently specified for production plants. These shall be used in conjunction with the additional requirements given in this standard, unless otherwise indicated.

**102** Codes and standards other than those stated in this standard may be acceptable as alternative or supplementary requirements, provided that they can be demonstrated to achieve a comparable, or higher, safety level.

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

#### B 200 DNV Offshore Standards, etc.

**201** The standards listed in Table B1 apply.

Table B1 DNV Offshore Standards and other DNV references	
Code	Title
DNV-OS-A101	Safety Principles and Arrangement
DNV-OS-B101	Metallic Materials
DNV-OS-C101	Design of Offshore Steel Structures, General LRFD method
DNV-OS-C401	Fabrication and Testing of Offshore Structures
DNV-OS-D101	Marine and Machinery Systems and Equipment
DNV-OS-D202	Instrumentation and Telecommunication Systems
DNV-OS-D301	Fire Protection
DNV-OS-F101	Submarine Pipeline Systems
DNV-OS-F201	Dynamic Risers
Classification Note 6.1	Fire Test Methods for Plastic Pipes, Joints and Fittings.
Classification Note 41.2	Calculation of Gear Rating for Marine Transmission
DNV-RP-A201	Standard Documentation Types
DNV-RP-A202	Documentation of Offshore Projects
	Rules for Certification of Flexible Risers and Pipes
	Rules for Classification of Ships
	Rules for Certification of Lifting Appliances

**Guidance note:**

The latest revision of DNV standards may be found in the list of publications at the DNV web site: <http://www.dnv.com>

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**B 300 Other references**

**301** In Table B2 other references are listed.

<b>Table B2 Other references</b>	
Code	Title
AISC ASD	Manual of Steel Construction
AISC LRFD	Manual of Steel Construction
ANSI/AGMA	Standard for Marine Gear Units: Rating
ANSI/ASME B31.3	Chemical Plant and Petroleum Refinery Piping
API RP 2A-LRFD	Planning, Designing and Constructing Fixed Offshore Platforms - Load and Resistance Factor Design
API RP 2A-WSD	Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design
API RP 14B	Design, Installation, Repair and Operation of Subsurface Safety Valve System
API RP 14C	Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms
API RP 14E	Design and Installation of Offshore Production Platform Piping Systems
API RP 14H	Installation, Maintenance and Repair of Surface Safety Valves and Underwater Safety Valves Offshore
API RP 16Q	Design, Selection, Operation and Maintenance of Marine Drilling Riser Systems
API RP 17A	Design and Operation of Subsea Production Systems
API RP 17B	Flexible Pipe
API RP 500	Recommended Practice for Classification of Locations for Electrical Installations on Petroleum Facilities Classed as Class I, Division 1 and Division 2
API RP 520	Sizing, Selection and Installation of Pressure Relieving Devices in Refineries
API RP 521	Guide for Pressure Relieving and Depressurising Systems
API Spec 2C	Offshore Cranes
API Spec 12D	Field Welded Tanks for Storage of Production Liquids
API Spec 12F	Shop Welded Tanks for Storage of Production Liquids
API Spec 12J	Oil and Gas Separators
API Spec 16R	Marine Drilling Riser Couplings
API Spec 6A	Wellhead and Christmas Tree Equipment
API Spec 6FA	Fire Test for Valves
API Spec 6FC	Fire Test for Valve With Automatic Backseats
API Spec 6FD	Fire Test for Check Valves
API Std 530	Calculation of Heater Tube Thickness in Petroleum Refineries
API Std 610	Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services
API Std 611	General Purpose Steam Turbines for Petroleum, Chemical and Gas Industry Services
API Std 612	Special Purpose Steam Turbines for Petroleum, Chemical and Gas Industry Services
API Std 613	Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services
API Std 614	Lubrication, Shaft-Sealing, and Control-Oil Systems and Auxiliaries for Petroleum, Chemical and Gas Industry Services

**Table B2 Other references (Continued)**

Code	Title
API Std 616	Gas Turbines for the Petroleum, Chemical and Gas Industry Services
API Std 617	Centrifugal Compressors for Petroleum, Chemical and Gas Industry Services
API Std 618	Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services
API Std 619	Rotary-Type Positive Displacement Compressors for Petroleum, Chemical and Gas Industry Services
API Std 620	Design and Construction of Large, Welded Low-Pressure Storage Tanks
API Std 650	Welded Steel Tanks for Oil Storage
API Std 660	Shell-and-Tube Heat Exchangers for General Refinery Services
API Std 661	Air-Cooled Heat Exchangers for General Refinery Service
API Std 671	Special Purpose Couplings for Petroleum, Chemical and Gas Industry Services
API Std 672	Packaged, Integrally Geared Centrifugal Air Compressors for Petroleum, Chemical and Gas Industry Services
API Std 674	Positive Displacement Pumps - Reciprocating
API Std 675	Positive Displacement Pumps - Controlled Volume
API Std 676	Positive Displacement Pumps - Rotary
API Std 2000	Venting Atmospheric and Low-Pressure Storage Tanks: Non-refrigerated and Refrigerated
ASME	Boiler and Pressure Vessel Code, Section I, Power Boilers
ASME	Boiler and Pressure Vessel Code, Section IV, Rules for Construction of Heating Boilers
ASME	Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels
ASME PTC 22	Performance Test Code on Gas Turbines (Performance Test Codes)
ASME/ANSI B73.1	Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process
ASME/ANSI B73.2	Specification for Vertical In-line Centrifugal Pumps for Chemical Process
ASME/ANSI B133.4	Gas Turbine Control and Protection Systems
BS 1113	Specification for design and manufacture of water-tube steam generating plant
BS 2654	Manufacture of vertical steel welded non-refrigerated storage tanks with butt-welded shells for the petroleum industry
BS 2790	Specification for design and manufacture of shell boilers of welded construction
BS 5950	Structural use of steelwork in building
BSI PD 5500	Specification for inferred fusion welded pressure vessels
DIN 4119	Above-ground Cylindrical Flat-bottomed Tank Installations of Metallic Materials
EEMUA publication 107	Recommendations for the Protection of Diesel Engines for Use in Zone 2 Hazardous Areas
ICS/OCIMF	Ship to Ship Transfer Guide (Petroleum)
IEC 60079-2	Electric apparatus for explosive gas atmosphere, Part 2 Electrical apparatus, type of protection 'p'
ISO 898	Mechanical properties of fasteners made of carbon steel and alloy steel
ISO 2314	Gas turbine - Acceptance tests
ISO 3046-1	Reciprocating internal combustion engines - Part 1 - Performance
ISO 6336 Pt. 1-5	Calculation of load capacity of spur and helical gears



Table B2 Other references (Continued)	
Code	Title
ISO 10433	Petroleum and Natural Gas Industries - Drilling and Production Equipment - Specification for Wellhead Surface Safety Valves and Underwater Safety Valves for Offshore Service (Based on API Spec 14D)
ISO 10474	Steel and steel products - Inspection documents
ISO/R 831	Rules for construction of stationary boilers
NACE RP0176	Corrosion Control of Steel Fixed Offshore Platforms Associated with Petroleum Production
NFPA 37	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NS 3471	Prosjektering av aluminiumkonstruksjoner - Beregning og dimensjonering (Aluminium structures - Design rules)
NS 3472	Steel structures - Design rules
OCIMF	Guide to purchasing, manufacturing and testing of loading and discharge hoses for offshore mooring
TBK 1 - 2	Generelle regler for trykkbeholdere. (General rules for pressure vessels) should be used together with Regulation of 11 February 1993 of boiler plant. (Issued by the Norwegian Directorate for fire and explosion prevention (DBE))
TBK 5-6	Generelle regler for rørsystemer. (General Rules for Piping Systems)
TEMA	Standards for Heat exchangers

## C. Definitions

### C 100 Verbal forms

**101 Shall:** Indicates requirements strictly to be followed in order to conform to this standard and from which no deviation is permitted.

**102 Should:** Indicates 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. Other possibilities may be applied subject to agreement.

**103 May:** Verbal form used to indicate a course of action permissible within the limits of the standard.

**104 Agreement or by agreement:** Unless otherwise indicated, agreed in writing between manufacturer or contractor and purchaser.

### C 200 Definitions

**201 Abnormal conditions:** A condition that occurs in a process system when an operating variable goes outside its normal operating limits.

**202 Alarm:** A combined optical and acoustic signal to warn operators of an abnormal condition and to identify the cause of the alarm.

**203 Blow-by:** A process upset resulting in gas flowing through a control valve designed to regulate flow of liquid.

**204 Bulkhead:** An upright partition wall.

**205 Choke valve:** Control valve designed to regulate or reduce pressure.

**206 Christmas tree:** Combination of valves and connectors designed to control the flow of well fluids, i.e. act as a barrier to the hydrocarbon reservoir.

**207 Client:** May be either the yard, the owner, or, with regard to components, the manufacturer.

**208 Closed drains:** Drains for pressure rated process components, piping or other sources which could exceed atmospheric

pressure, such as liquid outlets from pressure vessels and liquid relief valves, where such discharges are hard piped without an atmospheric break to a drain tank.

**209 Cold venting:** Discharge of vapour to the atmosphere without combustion.

**210 Completed wells:** Wells fitted Christmas trees attached to the wellhead, such that the flow of fluids into and out of the reservoir may be controlled for production purposes.

**211 Contractor:** A party contractually appointed by the purchaser to fulfil all or any of, the activities associated with design, construction and operation.

**212 Control room:** Continuously manned room for control of the installation. The room offers operator interface to the process control and safety systems.

**213 Control stations (or control room):** Those spaces in which radio, main navigating equipment, process control and shutdown equipment, fire and gas detection and control equipment, central internal communication and alarm equipment, dynamic positioning control system, emergency source of power or emergency switchboard are located.

**214 Control system:** Is a system that receives inputs from operators and process sensors and maintains a system within given operational parameters. It may also register important parameters and communicate status to the operator.

**215 Design pressure:** The maximum allowable working or operating pressure of a system used for design. The set point of PSVs can not exceed this pressure. (Identical to MAWP).

**216 Disposal system:** A system to collect from relief, vent and depressurising systems. Consists typically of collection headers, knock-out drum and vent discharge piping or flare system.

**217 Double block and bleed:** Two isolation valves in series with a vent valve between them.

**218 Emergency shutdown, (ESD):** An action or system designed to isolate production plant and ignition sources when serious undesirable events have been detected. It relates to the complete installation. See also safety system.

**219 Escape route:** A designated path to allow personnel egress to a safe area in the most direct way possible.

**220 Explosive mixture:** A vapour-air or gas-air mixture that is capable of being ignited by an ignition source that is at or above the ignition temperature of the vapour-air or gas-air mixture.

**221 Fail safe:** Implies that a component or system goes to or remains in the mode that is deemed to be safest on failures in the system.

**222 Failure:** An event causing one or both of the following effects:

- loss of component or system function
- deterioration of functionality to such an extent that safety is affected.

**223 Flammable liquid:** A liquid having a flash point below 37.8 °C (100 °F) and having a vapour pressure not exceeding 2.8 kg/cm<sup>2</sup> (40 psi absolute) at 37.8 °C (100 °F).

**224 Flare system:** A system which ensure safe disposal of vapour by combustion.

**225 Flash point:** The minimum temperature at which a combustible liquid gives off vapour in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.

**226 Hazardous area:** Space in which a flammable atmosphere may be expected at such frequency that special precautions are required. See DNV-OS-A101 for a complete definition including zones etc.

**227 Ignition temperature:** The minimum temperature required at normal atmospheric pressure to initiate the combustion of an ignitable mixture.

**228 Independent systems:** Implies that there are no functional relationships between the systems, and they can not be subject to common mode failures.

**229 Inert gas:** A gas of insufficient oxygen content to support combustion when mixed with flammable vapours or gases.

**230 Installation:** A bottom-founded platform permanently affixed to the sea-floor.

**231 Interim class certificate:** A temporary confirmation of classification issued by the surveyor attending commissioning of the plant upon successful completion.

**232 Interlock system:** A set of devices or keys that ensure that operations (e.g. opening and closing of valves) are carried out in the right sequence.

**233 L.E.L. (lower explosive limit):** The lowest concentration of combustible vapours or gases by volume in mixture with air that can be ignited at ambient conditions.

**234 Master valve:** A fail safe remotely operated shutdown valve installed in the main body of the Christmas tree, acting as a well barrier.

**235 Maximum allowable working pressure, (MAWP):** The maximum operating pressure of a system used for design. The set point of PSVs can not exceed this pressure. (Identical to design pressure).

**236 Maximum shut in wellhead pressure:** The maximum reservoir pressure that could be present at the wellhead.

**237 Minimum design temperature, MDT:** Minimum design operating or ambient start-up temperature. The lowest predictable metal temperature occurring during normal operations including start-up and shutdown situations is to be used. (If no thermal insulation is fitted, then ambient temperature is to be used if this is lower than the temperature of the content.)

**238 Open drains:** Gravity drains from sources, which are at or near atmospheric pressure, such as open deck drains, drip pan drains and rain gutters.

**239 Pressure safety valve, (PSV):** A re-closing valve designed to open and relieve pressure at a defined pressure and rate.

**240 Process shutdown, (PSD):** Isolation of one or more process segments by closing designated shutdown valves and tripping equipment. The shutdown is initiated through the process shutdown system that is a safety system designated to monitor the production plant.

**241 Processing plant:** Systems and components necessary for safe production of hydrocarbon oil and gas.

**242 Production system:** The system necessary for safe delivery of hydrocarbon oil and gas. The production system may include separation process, compression, storage and export facilities, hydrocarbon disposal, produced water treatment etc.

**243 Purchaser:** The owner or another party acting on his behalf.

**244 Riser system:** Includes the riser, its supports, riser end connectors, all integrated components, corrosion protection system, control system and tensioner system. Riser is a rigid or flexible pipe between the connector on the installation and the seabed (baseplate, wellhead manifold).

**245 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.

**246 Safety review:** Systematic identification and evaluation of hazards and events that could result in loss of life, property damage, environmental damage, or the need to evacuate.

**247 Safety factor:** The relationship between maximum allowable stress level and a defined material property, normally specified minimum yield strength.

**248 Shutdown system:** An electronic or mechanical system installed to monitor critical parameters and raise alarms or execute protective measures based on a pre-defined logic, i.e. PSD and ESD, to bring an undesirable event under control.

**249 Shut-in condition:** A condition resulting from the shutting-in of the plant (see API RP 14C) which is caused by the occurrence of one or more undesirable events.

**250 Slugging flow:** Alternating flow of gas and liquid in piping system, typically experienced in systems with large changes in height or with flow over long distances, e.g. in pipelines and risers.

**251 Subsea control system:** The complete system designed to control the flow of hydrocarbons from subsea wells and pipelines (as applicable). It will typically include surface and subsea control modules, umbilicals and termination points.

**252 Surface controlled sub surface safety valve, (SCSSSV):** A fail safe shutdown valve installed in the well bore.

**253 Transient condition:** A temporary and short-lived condition (such as a surge) which usually does not cause an undesirable event.

**254 Undesirable event:** An adverse occurrence or situation or hazard situation that poses a threat to the safety of personnel or the plant.

**255 Unit:** Any floating offshore structure or vessel, whether designed for operating afloat or supported by the sea bed.

**256 Utility systems:** Systems providing the installation with supporting functions. Typical systems are cooling water, glycol regeneration, hot oil for heating, chemical systems for injection, instrument air and power generation system.

**257 Verification:** An examination to confirm that an activity, a product or a service is in accordance with specified requirements.

**258 Verifier:** Body or person who performs verification.

**259 Water hammer:** Pressure pulse or wave caused by a rapid change in flow velocity.

**260 Wellhead:** Connection point between conductor, casing, tubing and the Christmas tree.

**261 Wing valve:** A fail safe shutdown valve installed on the side outlet of the Christmas tree, acting as a well barrier.

## C 300 Abbreviations

**301** The abbreviations in Table C1 are used.

Table C1 Abbreviations	
Abbreviation	Meaning
AGMA	American Gear Manufacturers Association
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
API	American Petroleum Institute
ASD	Allowable stress design
ASME	American Society of Mechanical Engineers
BS	British standard (issued by British Standard Institution)
D & ID	Duct and instrument diagram
DVR	Design verification report
EEMUA	Engineering Equipment and Materials Users Association
EJMA	Expansion Joint Manufacturer's Association Inc.
ESD	Emergency shutdown
F & G	Fire and gas
FAT	Factory acceptance test

FMEA	Failure mode and effect analysis
HAZOP	Hazard and operability (study)
HIPPS	High integrity pressure protection system
HIPS	High integrity protection system
HVAC	Heating, ventilation and air conditioning
ICS	International Chamber of Shipping
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers Inc.
ISO	International Standardisation Organisation
LRFD	Load and resistance factor design
MAWP	Maximum allowable working pressure
MDT	Minimum design temperature
MOU	Mobile Offshore Unit
MSA	Manufacturing survey arrangement
NACE	National Association of Corrosion Engineers
NDT	Non-destructive testing
NFPA	National Fire Protection Association
OCIMF	Oil Companies' International Marine Forum
P & ID	Piping and instrument diagrams
PAHH	Pressure alarm high high
PSD	Process shutdown
PSV	Pressure safety or relief valve
PWHT	Post weld heat treatment
RP	Recommended practice (API)
SCSSSV	Surface controlled sub surface safety valve
Spec	Specification (API)
Std	Standard (API)
SWL	Safe working load
TBK	Den norske Trykkbeholderkomite
TEMA	Tubular Exchanger Manufacturers Association, Inc.
UPS	Uninterruptible power supply
VDU	Visual Display Unit
WPQT	Welding procedure qualification test
WPS	Welding procedure specification
WPT	Welding production test
WSD	Working stress design

## D. Documentation

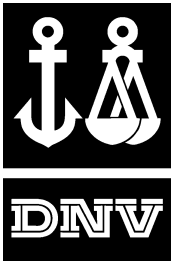
### D 100 General

**101** It is recommended that the following design documentation is produced to document production systems provided under this standard:

- a) Process system basis of design.
- b) Process simulations.
- c) Equipment layout or plot plans.
- d) Piping and instrument diagrams (P & ID), process flow diagrams (PFD).
- e) Shutdown cause and effect charts.
- f) Flare and blowdown system study or report (including relevant calculations for e.g. capacity requirements, back pressure, equipment sizing, depressurising profile, low temperature effects, liquid entrainment etc.).
- g) Sizing calculations for relief valves, bursting discs and restriction orifices.
- h) Flare radiation calculations and plots.
- i) Cold vent dispersion calculations and plots.
- j) HAZOP study report.
- k) Piping and valve material specification for process and utility systems (covering relevant data, e.g. maximum or minimum design temperature or pressure, corrosion allowance, materials for all components, ratings, dimensions, reference standards, branch schedules etc.).
- l) Line list.
- m) Arrangement showing the location of main electrical components.
- n) "One-line wiring diagrams", cable schedules, equipment schedules, power distribution and main cable layout.

**102** For requirements for documentation in relation to certification and classification, see Ch.3.





## HYDROCARBON PRODUCTION PLANT

### CHAPTER 2

## TECHNICAL PROVISIONS

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## SECTION 1 DESIGN PRINCIPLES

### A. General

#### A 100 Overall safety principle

**101** Hydrocarbon production systems shall be designed to minimise the risk of hazards to personnel and property by establishing the following barriers:

- preventing an abnormal condition from causing an undesirable event
- preventing an undesirable event from causing a release of hydrocarbons
- safely dispersing or disposing of hydrocarbon gases and vapours released
- safely collecting and containing hydrocarbon liquids released
- preventing formation of explosive mixtures
- preventing ignition of flammable liquids or gases and vapours released
- limiting exposure of personnel to fire hazards.

### B. Design Loads

#### B 100 General principles

**101** Design limitations for production plant and components shall be clearly defined and shall take account of reservoir properties, environmental effects, unit motions on floating installations and effects from all operational conditions, including transients. Typical transient conditions could be associated with start-up, shutdown, change-over, settle-out, blow-down, slugging flow etc.

**102** All elements of the production plant are to be suitable for the overall design loads for the plant, and shall be designed for the most onerous load combination.

**103** Design loads for individual components shall be defined with regard to function, capacity and strength. Mechanical, electrical and control interfaces shall be compatible.

**104** Design accidental loads shall be specified and implemented in order to prevent unacceptable consequences from accidental events. Suitable loads shall be established with regard to the accidental events that could occur. See DNV-OS-A101 for determination of relevant accidental loads.

**105** Systems and components shall be designed and manufactured in order to minimise the probability of undesirable events. Systems and components that statistically have high failure probabilities shall be avoided. Where this is unavoidable, such items should be located to minimise the consequence of a failure.

**106** Where conditions and load combinations are complex, calculations shall be made for each combination of loadings in order to confirm adequacy of design.

**107** The designer shall define maximum imposed loadings on critical equipment and components (e.g. nozzle loadings on pressure vessels, tanks, rotating machinery etc.). Supporting calculations shall be provided where necessary.

**108** Pipework shall be sized so that fluid velocities do not exceed maximum erosion velocity as defined in recognised codes, e.g. API RP 14E.

#### B 200 Environmental conditions

**201** The overall environmental design criteria and motion characteristics for the unit or installation shall also apply for

design of the production plant. Different design criteria may apply to different phases or conditions, e.g. normal operation, shutdown, survival and transit.

**202** Component or system suitability for intended purpose should be confirmed through test results or other relevant documentation.

**203** Where applicable, the following shall be taken into consideration when establishing the environmental loads:

- the unit's motions (i.e. heave, roll, pitch, sway, surge, yaw)
- wind forces
- air and sea temperatures
- wave loads
- current
- snow and ice.

#### B 300 Design pressure and temperature

**301** Systems and components shall be designed to withstand the most severe combination of pressure, temperature and other imposed loads.

**302** The design pressure shall normally include a margin above the maximum operating pressure, typically 10 % and normally minimum 3.5 bar.

**303** Vapour condensation, pump out, siphon effects etc. shall be considered when defining the minimum design pressure.

**304** The maximum and minimum design temperature shall include a margin to the operating conditions to reflect uncertainty in the predictions.

**305** Typical transients to consider when defining design conditions include:

- cold start-up
- shut-in, settle out
- shutdown
- surge
- water hammer
- 2 phase flow, slugging
- depressurising, relief, Joule Thomsen effects
- blow-by
- cooling failure
- thermal expansion.

**306** The basis for definition of design conditions shall be documented.

### C. Plant Arrangement and Control

#### C 100 Operational considerations

**101** The production plant shall be designed to enable safe operation during all foreseeable conditions. A hazard and operability (HAZOP) analysis shall be performed to document the adequacy of design.

**102** One single maloperation or malfunction within a system shall not lead to a critical situation for personnel or the unit or installation.

##### Guidance note:

Maloperation or malfunction refers to operational and/or technical failure.

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**103** Machinery and equipment shall be located and arranged to allow safe operation. The requirements of DNV-OS-A101 shall apply.

**104** All equipment and parts which are to be operated manually or which are subject to inspection and maintenance on board should be installed and arranged for safe and easy access.

**105** Facilities for safe isolation shall be provided for all parts of the production and utility systems that contain high pressure, flammable, or toxic substances and that require to be opened for maintenance or other operations while adjacent parts of the system are energised or pressurised.

**Guidance note:**

The isolation strategy for process systems should be based on an overall assessment of safety and permit to work systems. The following guidance is normally applicable as part of the strategy:

- For infrequent and short term operations, a single block and bleed will normally be adequate (e.g. for replacement of relief valves).
- For longer term operations, spectacle blinds or blinds or spacers shall be incorporated to enable positive isolation.
- For frequent operations, double block and bleed will be required (e.g. at pig launchers).
- For personnel entry into pressure vessels and tanks, positive isolations with blinds will be required at all interfaces with pressurised systems.
- Isolation of instrument drain, sample points and other points with no permanent connection should be equipped with flanged isolation valves or double isolation valves.

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

**Guidance note:**

Shields or insulation should normally be installed on surfaces that can be reached from work areas, walkways, stairs and ladders if surface temperatures exceed 70 °C or are below -10 °C during normal operation.

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## C 200 Monitoring, control and shutdown

**201** All equipment and systems shall be equipped with indicating or monitoring instruments and devices necessary for safe operation.

**202** Production systems shall be equipped with shutdown systems. The shutdown systems shall be completely independent of control systems used for normal operation.

**Guidance note:**

Safety systems and control systems for equipment and systems with predictable and limited damage potential may be combined only if the probability for common mode failure is demonstrated to be low.

Additional shutdown signal from process control system to shutdown valves and breakers may, however, be acceptable.

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**203** Systems that could endanger the safety if they fail or operate outside pre-set conditions shall be provided with automatic shutdown. The shutdown system shall monitor critical parameters and bring the system to a safe condition if specified conditions are exceeded. The protection principles shall be based on API RP 14C.

**Guidance note:**

This will normally apply to all permanently installed processing systems on production installations.

Automatic shutdown systems may not be required for minor systems continuously attended during normal operation. This will be

subject to adequate monitoring and sufficient response time available for manual shutdown.

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**204** Systems designed for automatic shutdown shall also be designed to enable manual shutdown.

**205** All shutdowns shall be executed in a predetermined logical manner. The shutdown system shall normally be designed in a hierarchical manner where higher level shutdowns automatically initiate lower level shutdowns. Emergency shutdown shall initiate a process shutdown.

**206** Definition of the shutdown logic and required response times are to be based on consideration of dynamic effects and interactions between systems.

**207** Inter-trips between process systems shall be initiated as a result of any initial event which could cause undesirable cascade effects in other parts of the plant before operator intervention can be realistically expected.

**208** The shutdown principles given in DNV-OS-A101 shall be adhered to.

**209** The highest or most severe levels of emergency shutdown shall, as a minimum, result in the following actions related to the production plant. (note that other actions will also be required, see DNV-OS-A101):

- a) All actions described in 210.
- b) Closure of all surface and subsea tree valves, including SCSSSV.
- c) Depressurising of production plant.
- d) Closure of pipeline isolation valves, if installed.

**210** The highest or most severe level of process shutdown shall, as a minimum, result in the following actions:

- a) Closure of master and wing or injection valves (on surface trees).
- b) Closure of wing valve (or other acceptable barrier valve on subsea trees).
- c) Closure of process shutdown valves.
- d) Closure of riser ESD valves (incoming and outgoing).
- e) Closure of gas lift and gas injection valves.
- f) Trip of driven units like gas compressors, pumps, process heaters etc.
- g) Isolation or trip of utility systems serving the production plant.

**211** There shall be two independent levels of protection to prevent or minimise the effects of a single malfunction or fault in process equipment and piping systems (including their controls). The two levels of protection shall be provided by functionally different types of safety devices to reduce the probability for common cause failures.

**Guidance note:**

Shutdown at the primary protection level should be possible without the secondary level being initiated. As an example, the PAHH (Pressure alarm high high) as primary overpressure protection should react to shut-off inflow before the PSV reaches set pressure.

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**212** Activation of the shutdown system shall be sounded by alarms at the control station. Central indicators shall identify the initiating device or cause of the safety action and the shutdown level initiated.

**213** From the control station, it shall be possible to verify, the operating status of devices affected by the shutdown action (e.g. valve position, unit tripped, etc.). Such status shall be



readily available. The screen used for shutdown status shall be dedicated for this purpose.

**Guidance note:**

Such status should be available without having to page through several VDU pictures. Alarm list and highlights of shutdown imperfections should be used. Large screens are recommended instead of VDUs for display of shutdown status.

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**214** Shutdown commands should not be reset automatically. As a rule, important shutdown devices shall only be reset locally after the initiating shutdown command has been reset by the operator.

**215** Activation of depressurisation valves can be incorporated in either the process or emergency shutdown.

**216** Additional requirements for instrumentation, control and safety systems are found in DNV-OS-D202.

### C 300 Shutdown devices and failure modes

**301** Systems, actuated devices and controls shall be designed fail safe. This means that failure of the controls or associated systems will result in the system going to the operational mode that has been pre-determined as safest. This normally implies that shutdown valves will 'fail to closed' position, and depressurisation valves 'fail to open' position. Sensors shall have normally energised, closed circuits and contacts.

**302** Where required, stored energy devices for actuators shall be designed, located and protected to ensure that the fail safe function is not impaired by defined design accidental events.

**303** Pneumatic and hydraulic systems shall be monitored. Process shutdown of such systems shall be initiated if pressure falls below a level where functionality is lost.

**304** Components which, for safety reasons, are required to maintain functionality for a specific period of time during an emergency (e.g. fire resistance of valves) shall be verified as having the appropriate qualifying properties, e.g. by tests, calculations etc.

### C 400 General requirements for valves

**401** Valves shall have position indicating devices that are easy to see and to understand.

**402** Remote operated valves, and valves which are part of an automatic safety system, shall have position transmitters giving status at the control or shutdown panel.

**403** Control valves and shut off valves shall be designed to prevent unacceptable pressure surges on closure either by command or by loss of control signal.

**404** Requirements for fire protection and testing of shutdown valves isolating segments shall be as defined in DNV-OS-D301.

**405** See also specific requirements for valves given in Sec.6.

### C 500 Wellhead control system

**501** The principles described in DNV-OS-D202 shall apply to control of wellhead valves on surface trees, including the surface controlled sub surface safety valve (SCSSSV). The position of the SCSSSV may, however, be derived from the pressure of the control line.

**502** Hydraulic oil return lines from the SCSSSV could be contaminated by hydrocarbons if a leak occurs downhole. The return system shall therefore be segregated from other systems, and shall be regarded as a secondary grade source for area classification purposes.

**503** In order to minimise wear, closure of wellhead valves shall be in the following sequence: wing valve before master valve before SCSSSV. Failure of a valve to close shall not prevent closure of the remaining valves.

**504** Oil levels and supply pressures from hydraulic wellhead control panel shall be monitored. Wellhead valves shall be shutdown in a controlled manner if either pressure falls below a level where functionality may be lost.

**505** The wellhead shutdown system shall normally be designed for complete isolation of all wells within 30 s.

### C 600 Subsea control system

**601** The requirements in 602 to 608 apply to control of subsea wellhead and injection valves, manifold valves, and pipeline isolation valves which act as barriers to the reservoir or between the installation and significant inventories in pipelines. The requirements also apply to control of sub surface valves in subsea wells.

**Guidance note:**

Installation of pipeline isolation valves is not a requirement of this standard, but if such valves are installed to reduce risks on the installation then relevant requirements for the control systems will apply.

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**602** The subsea control system shall be fail safe. Controlled shutdown shall be possible after failures in system elements (e.g. failure of pilot controls, multiplex signals or electro-hydraulic signals).

**Guidance note:**

Where appropriate, this could be achieved by depressurising the control fluid supply line through a dump valve that is independent of other subsea controls.

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**603** The response time of the complete system (i.e. time to complete the demanded action) shall be defined. Where relevant, two response levels may be defined to reflect normal operation and fail safe operation when e.g. multiplex controls have failed.

**604** The subsea control system shall receive inputs from the shutdown system. Shutdown of topside production systems or riser ESD valves shall normally result in closure of subsea wing valve or other barrier valve local to the wellhead.

**605** High level ESD on the installation shall result in closure of all subsea barrier valves, including the sub surface valve.

**606** The general requirement for segregation between control and shutdown systems is not mandatory for subsea control systems, which may incorporate operational control functions (e.g. choke valve controls or status, pressure and temperature monitoring).

**607** Control fluids used in open control systems that drain to sea shall be harmless to the environment.

**608** Possible leakage of well bore fluids into a closed control system from the SCSSSV shall be considered in the design. See 502.

## SECTION 2 PRODUCTION AND UTILITY SYSTEMS

### A. General

#### A 100 General requirements

**101** The plant shall be divided into segments. Each segment shall be segregated by shutdown valves that are operated from the shutdown system. The valves shall segregate production systems based on consideration of plant layout, fire zones, depressurising system and pressure ratings.

**Guidance note:**

The shutdown valves should divide the process into segments such that a leakage from any segment does not represent unacceptable consequences. The adequacy of selected segmentation should be addressed through a HAZOP study.

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**102** The following valves shall be actuated and designated as shutdown valves:

- wing, master, injection and sub surface (downhole) valves associated with wellhead trees
- pipeline riser valves
- riser gas lift valves
- segregation valves between systems with different design pressure (MAWP)
- process segmenting valves.

**103** The production and utility systems shall be fitted with sufficient drain and vent points to enable draining and depressurisation of all segments in a controlled manner. They shall be permanently or temporarily connected to the closed flare, ventilation and drain disposal systems. See H.

**Guidance note:**

Consideration should be given to installing 2 block valves in series at drain points from high pressure systems (typically 300# rating and above). This will enable shut off if ice or hydrates form in one of the valves as pressure is bled off.

Facilities to enable purging of systems with inert gas (e.g. nitrogen) should be incorporated if such operations are required by operating or 'Permit to Work' procedures.

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**104** All atmospheric vessels where an explosive atmosphere may occur due to presence of flammable substance shall be inerted with blanket gas or inert gas if there is a possibility of air ingress.

**105** Interfaces between high pressure and low pressure systems that are not open and protected during normal operations shall be isolated by spades, blinds or other positive means. An interlocked double block and bleed may also be accepted. These valves are to be rated for the highest pressure.

**106** Piping with a bore less than 19 mm ( $\frac{3}{4}$  inch) shall be avoided in process piping systems where practicable. If used, particular attention shall be paid to providing suitable supporting arrangements to prevent damage caused by vibrations, relative thermal expansions or other imposed loads from adjacent pipework or operations.

**107** Utility systems are to be in accordance with requirements in this section. Additional requirements for general utility services are given in DNV-OS-D101.

#### A 200 Interconnection between hazardous and non-hazardous systems

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

**202** Any connections between hazardous and non-hazardous systems shall be avoided. Where this is impracticable, such connections shall be designed to eliminate or control the risk of ingress of hazardous material from one system to the other due to incorrect operation or leaks. The following issues shall be fulfilled before systems are interconnected:

- a) Identify possible failure modes and define a realistic range of leak sizes.
- b) Evaluate possible consequences of cross contamination.
- c) Describe and evaluate reliability, maintainability and testability of active and passive protection systems (e.g. liquid seals, non-return valves, detectors, actuated valves, primary and secondary loops etc.).

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

**Guidance note:**

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

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### B. Wellhead and Separation System

#### B 100 General

**101** Mechanical handling of heavy components in wellhead areas shall include attention to avoiding damage to process equipment. Where possible, hydrocarbon piping associated with other systems should not be routed through the wellhead area.

**102** Wellheads shall be designed for maximum shut in wellhead pressure, considering the accuracy of predicted reservoir conditions (pressure, density etc.). A safety margin of 10 % should be incorporated in the design pressure.

**103** Flow lines, piping, instrumentation and structures which are connected to, or adjacent to, wellheads shall be designed to allow relative vertical and lateral movement between wellhead and installation. (This can be e.g. due to thermal expansion, movement caused by waves etc.).

**104** Conductor tensioning systems, where required, shall be subject to a failure mode and effect analysis (FMEA), or an equivalent study.

**Guidance note:**

The FMEA should identify critical components and functions. Appropriate fail safe actions, redundancy and alarms should be incorporated to ensure the integrity of the well barrier.

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## C. Separator System

### C 100 General

**101** The separators shall have sufficient capacity to separate the components of the well stream, and effective means for removal of sand and water.

**102** Design of separator and separator control system shall include consideration for list and rolling of the unit, where relevant.

## D. Gas Treatment and Compression System

### D 100 General

**101** Liquid scrubbers with appropriate internals (e.g. mist pads) shall be installed immediately upstream of gas compressors. The compressor train shall be tripped or otherwise protected if liquid levels reach an unacceptable level within an upstream scrubber.

**102** Gas coolers in systems with significant pressure differential between the gas and cooling medium side shall be fitted with quick acting relief devices (e.g. bursting discs). See API RP 521.

**103** Compressor seal systems shall be monitored for leakage. The compressor shall be automatically tripped and depressurised if unacceptable leaks or other malfunctions are detected.

**104** Compressor recycle line shall be self-draining to the tie-in point upstream of the compressor, with the recycle line valve located at the high point.

**105** The design pressure and temperature of the process segment that contains the compressor shall include account of settle-out conditions.

**106** Compressor recycle valves which are required to operate as part of emergency depressurisation shall be fitted with separate solenoids controlled from the shutdown system.

**107** Location of vent points from the glycol regeneration reboiler shall include consideration of emissions of harmful substances (e.g. aromatics) and their effect on personnel.

**108** Fuel gas treatment systems shall include instrumentation that will trip the fuel gas supply if fuel gas properties exceed acceptable limits for the fired unit or engine.

## E. Water Injection, Gas Injection and Gas Lift System

### E 100 General

**101** A non-return valve and an automatic shutdown valve shall be fitted at the injection point to the well.

**102** Water injection pipework and wellheads on units which are intended to operate in areas with ambient design temperatures below -5 °C shall be fitted with winterisation to prevent freezing during periods of shutdown.

#### Guidance note:

This requirement may be waived if suitable operational procedures are established.

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**103** If produced water is to be re-injected into the reservoir, then overboard dump lines and drain lines from water injection pump seals shall be considered for area classification due to dissolved hydrocarbon gases.

**104** Safety showers and eye washing stations shall be installed at locations where biocides or other harmful substances are stored and handled.

## F. Heating and Cooling Systems

### F 100 General

**101** Interconnections between systems serving hazardous and non-hazardous plants are normally not accepted. See A200.

**102** Primary heating or cooling circuits in hydrocarbon process systems shall have facilities to detect small hydrocarbon leakages. See D103 for protection against major leakages.

**103** The design temperature of both sides of heat exchangers shall be determined by the hottest fluid.

**104** Heat exchangers shall be protected from thermal expansion of blocked in fluids when flow is maintained through the other side.

## G. Chemical Injection Systems

### G 100 General

**101** Non-return valves shall be installed at injection points to production systems.

**102** The design pressure of a chemical injection pump shall, as a minimum, be the same as the system into which it injects.

**103** A banded area with adequate drainage shall be provided for storage and emptying of transportable tank containers. Incompatible chemicals shall be located in separate bunds.

**104** Piping from transportable tank containers or boat loading stations to permanent storage tanks or other facilities shall be self draining.

**105** Provisions for lashing of transportable tank containers shall be incorporated in the banded area. Permanent piping installations and hose couplings shall be protected against damage from handling operations.

**106** Injection systems supplied with cryogenic liquids (e.g. liquid nitrogen) shall be installed in insulated bunds that are designed to collect any leaks and prevent adverse low temperature effects on structures or other equipment.

**107** Safety showers and eye washing stations shall be installed at locations where harmful substances are stored and handled.

## H. Drainage Systems

### H 100 Open drainage system

**101** See DNV-OS-D101 for requirements for bilge systems on floating installations.

**102** Production equipment from which spillage and minor leaks can be expected shall be located above drip trays or coamings which will collect and direct escaped fluids to an open drainage system. Drain points are to be installed at opposite sides of the tray.

#### Guidance note:

This will normally apply to:

- atmospheric tanks and pressure vessels with multiple flanges and instruments
- pumps
- heat exchangers
- seal and lubrication oil systems under rotating machinery
- sample points
- pig receivers and launchers, etc.

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**103** The capacity of the drip tray shall be based on an assessment of potential leak rates and may normally be nominal for equipment other than pressure vessels and tanks, (e.g. approximately 50 mm coaming).

**104** The capacity of drip trays under large tanks, pressure vessels and heat exchangers should be based on an assessment of the number of leak sources, and volume and consequence of leak e.g. onto equipment or deck below.

**Guidance note:**

A capacity to hold 5 % of the volume can normally be regarded as adequate, provided that there is also sufficient capacity of the collection system with headers etc. Catastrophic ruptures can be handled through the general open deck drain system.

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**105** An open deck drain system shall be installed to collect leakage from representative process pipework based on operating conditions. The system shall also be designed to handle rain water and fire water, and, for floating installations, also sea water.

**Guidance note:**

The objectives that should be considered when designing the open deck drain system include:

- removal of liquids that could fuel a fire
- control the spread of flammable liquids from one fire zone to the next
- maintain escape routes passable
- limit liquid rundown onto sensitive equipment or structures below the source of the leak e.g. life saving appliances, risers, tank deck, escape routes
- minimising environmental damage.

Smaller process leaks and rain water are typically collected in gullies and led to a treatment system. Gullies are normally located at regular intervals throughout the production plant area.

Fire water and large process leaks of oil are typically collected in gullies and routed to a safe location for disposal (e.g. overboard) through overflows and gutters.

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**106** Drains systems for areas that are classified as hazardous shall be separate from drain system for non-hazardous areas.

**Guidance note:**

The collection system (consisting of collection piping and drain tank with vent) for the hazardous open drain system should be completely separate from the collection system for the non-hazardous system.

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**107** If there is a possibility of air ingress, the treatment plant shall be inerted with blanket gas or inert gas. Measures shall be taken to prevent spread of fire through the drainage system (e.g. water seals with level alarms).

**H 200 Additional requirements for closed drainage systems**

**201** The production plant shall, as a minimum, be equipped with a closed drainage system for hydrocarbons. See A103.

**202** The open and closed drainage systems shall be separate. See A200 for requirements for separation.

**203** For floating installations, drainage systems shall operate satisfactorily during all sea states and operational trim of the installation.

**204** See DNV-OS-D101 for requirements for collection of drainage products within slop tanks on floating installations.

## SECTION 3 RELIEF AND DEPRESSURISING SYSTEMS

### A. General

#### A 100 General requirements

**101** The production plant shall be provided with pressure relief, vent, depressurising and disposal systems designed to:

- protect equipment against excessive pressure
- minimise the escape of hydrocarbons in case of rupture
- ensure a safe collection and discharge of released hydrocarbon fluids.

**102** The systems shall be designed to handle the maximum relief rates expected due to any single equipment failure or dimensioning accident situation (e.g. caused by blocked outlet or fire). Consideration shall also be given to possible cascade effects where upsets in one process segment can cause upsets elsewhere.

**103** Block valves installed in connection with pressure relieving devices (PSV, rupture disc or depressurisation valve) shall be interlocked or locked open as appropriate. Block valves or control valves are not to be installed in relief collection headers.

**Guidance note:**

Flare gas recovery systems are exemptions.

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**104** Discharges from relief valves, rupture discs, and automatic and manual depressurisation valves are to be routed to a safe location.

**105** Supply and discharge piping to and from relieving devices shall be self-draining away from the relief device back to pressure source and to knockout drum, as applicable. The tie-in to collection header shall normally be at the top of the header, preferably at 45 ° to the flow direction in the header.

**106** Relief and blowdown devices shall be located to enable effective relief of the complete volume they protect without obstructions to flow, e.g. flow through control valves, mist pads etc.

**107** The design of piping, valves, supports and knock out drum shall include consideration of generation of low temperatures, hydrates, possible slugging flow, and heat input from the flare during normal and emergency conditions.

### B. Pressure Relief System

#### B 100 General

**101** All pressure systems shall be fitted with pressure relief devices that are set at no higher than the design pressure (MAWP) of the system. The devices shall have suitable capacity and characteristics to limit pressure build up to within limits allowed in the design code for the system or component.

**Guidance note:**

The limits are normally:

- 110 % of MAWP for non-fire relief
- 120 % of MAWP for fire relief.

Design cases that should be considered include:

- blocked outlet
- failure of pressure control valve
- gas blow by at level control valve
- excessive energy input (from heater or fire)
- rupture of heat exchanger tube
- blocked in volume (liquid expansion)

- backflow.

Two phase flow should be identified for the design cases listed above.

If design for full flow relief proves impractical, then alternative measures may be considered. These include high integrity pressure systems (HIPPS). The acceptability of such systems shall be considered on a case by case basis and will be dependent upon demonstration of adequate reliability and response of the complete system from detector to actuated device. The reliability target should be an order of magnitude higher than critical failure of a typical relief device. Such systems may not replace the PSV on a pressure vessel.

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**102** If more than one device is necessary to obtain the required relief rate, then the system shall be equipped with valves of sufficient capacity to enable any one device to be out of service without reducing the capacity of the system to below 100 % of design rate.

**103** Block valves are not normally to be installed where equipment is protected by a single relief valve. Downstream block valves may, however, be installed if discharge is to a common relief header. See also A103.

**104** To prevent over pressurisation of the PSV discharge side, all downstream isolation valves in multiple PSV installations shall be open unless the PSV is removed for maintenance.

**105** Imposed loadings on relief valve nozzles shall be avoided by means of careful layout of piping and design of supports.

**106** Rupture discs are to be used in systems containing substances that could render a pressure relief valve ineffective, or when rapid pressure rise can be predicted.

**107** In installations where rupture discs are installed in series with PSV or other rupture disc, the volume between the devices shall be monitored for leakage and increase in pressure. An alarm shall be given at the control centre if a leak is detected.

### C. Depressurising System

#### C 100 General

**101** The depressurising system shall ensure safe collection and disposal of hydrocarbons during normal operations and during emergency conditions.

**Guidance note:**

Elements of the system will normally be regarded as part of the safety systems and should be designed to integrate with the overall safety strategy for the plant.

It is normally recommended that detection of fire or gas release in the process area results in automatic depressurisation of the production plant. See also Sec.1 C209. Where this is not the case, the HAZOP should include due consideration of the effects of the added time before depressurisation is initiated, allowing for manual actions.

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**102** The depressurising system shall be as simple as practicable and shall be designed according to the fail safe principle. This normally implies that blow down valves are spring return, and fail to open position.

**103** Process systems that contain significant energy shall be depressurised during an emergency situation. The rate of depressurising shall be sufficient to ensure that rupture will not occur in case of external heat input from a fire.

**Guidance note:**

The maximum locked-in energy content should be based on assessment of the potential for incident escalation. Blocked in volume equivalent to 1000 kg of hydrocarbons is commonly regarded as acceptable if the plant is located in an open area.

The capacity of the system should be based on evaluation of:

- system response time
- heat input from defined accident scenarios
- material properties and material utilisation ratio
- other protection measures, e.g. active and passive fire protection
- system integrity requirements.

Fire water systems are not normally regarded as reliable protection measures for systems exposed to jet fires.

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**104** It shall be possible to activate the depressurising system manually from the control station, in addition to any automatic actions initiated through the ESD or F&G systems.

**105** The piping layout should aim to provide protection from external loads (e.g. from fire, explosion, missile impact, dropped or swinging loads).

**106** During an dimensioning accidental event, the integrity and functionality of depressurising piping and valves shall be maintained for the required period of time in order to ensure that successful depressurisation can be performed.

**Guidance note:**

To ensure this functionality, passive fire protection or other measures may be required to ensure that depressurisation is initiated before excessive temperatures are reached.

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**107** See Sec.1 for general requirements for controls and valves.

## D. Disposal System

### D 100 General

**101** The disposal system(s) shall collect from relief, ventilation, pressure control and depressurising systems. Liquids shall be separated in a knock out drum before discharge.

**Guidance note:**

The design should be suitable for the disposal rate due to pressure control valve failure.

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**102** The gas disposal system shall be designed such that the lowest pressure sources can enter the system without unacceptable reduction in capacity due to back pressure.

**Guidance note:**

This may result in a requirement for 3 systems, one for high pressure sources, one for low pressure sources and one for atmospheric ventilation.

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**103** The gas disposal systems shall be continuously purged with nitrogen or fuel gas supplied upstream in headers and sub-headers.

**104** The knock out drum shall have capacity to remove slugs and droplets that would not be completely burned in the flare or which could fall back onto the installation.

**Guidance note:**

Typical performance standards for knock out drums are:

- separation of liquid droplets down to 300-400 micron with normal liquid level at start of depressurising

- capacity to hold entrained liquid from process segments while isolation valves are closing, minimum 90 s
- capacity to hold liquid from condensing vapours
- capacity to hold liquid from a typical process segment that has not been successfully isolated while depressurising valve is open (e.g. inflow from well or pipeline). The liquid holding capacity should be based on evaluation of the time required for manual intervention and the number and flow rates of possible sources. It should be considered to install alarms on valves that could cause significant inflow if they fail to operate or operate inadvertently. See also Sec.2
- in estimating capacity to hold liquid, the pump out rate should not be taken into consideration.

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**105** The sizing and internal design of knock out drum to ensure efficient liquid removal shall also include consideration of:

- dynamic effects caused by unit motions (e.g. sloshing) for floating installations
- the possibility of gas flow picking up liquid slugs when passing through the drum.

**106** The knock out drum shall be fitted with high level monitoring which initiates a complete process shutdown if design levels are exceeded.

**107** Cold vents shall be located at a safe distance from ignition sources and ventilation intakes. An extinguishing system shall be fitted to extinguish the vent if it is accidentally ignited by e.g. lightning or static discharge.

**108** The dew point of vented gas is to be such that it will not condense and fall back on the plant when discharged at the minimum anticipated ambient temperature.

**109** Open vent discharge piping shall be protected against the effects of rain and ingress by foreign bodies.

**Guidance note:**

It may be appropriate to install:

- a 10 mm 'weep-hole' to drain out any rainwater
- a wire mesh (or 'bird cage') at outlet
- flame arrestors.

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**110** Flares shall normally be ignited by a continuous pilot flame. The pilot flame shall be supplied with a reliable source of gas. A back-up system shall be provided to secure supply of gas during all operating conditions.

**111** In the case of a gas recovery system, the flare may be ignited by a pilot flame or an automatic ignition system.

**112** An automatic ignition system shall be activated by both the PSD and ESD system.

**113** The ignition system shall have the same high reliability as the PSD or ESD system. Sources of single failure should be avoided.

**114** The gas cloud formation and explosion consequences that could occur due to an ignition failure shall be analysed and assessed as acceptable.

**115** The ignition timing shall be decided from flow calculations for representative release scenarios.

**116** The ignition system shall be provided with adequate redundancy to ensure operation as and when required.

**Guidance note:**

This may mean:

- back-up or reservoir nitrogen
- minimum two attempts in each sequence
- parallel components as required to remove sources of single failure.

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**117** Flare and cold vent structures shall be fitted with stairs, ladders, handrails or guards to provide safe personnel access for maintenance and inspection. Where appropriate, securing points for personnel harness shall be provided.

**118** The flare and vent systems shall comply with API RP 521 or equivalent. The radiant heat intensities or emissions from the flare and vent systems are not to exceed the following limits, see also DNV-OS-A101:

- 6.3 kW/m<sup>2</sup> (2000 Btu/hr/ft<sup>2</sup>) in areas where emergency actions lasting up to one minute may be required by personnel without shielding but with appropriate clothing

- 4.7 kW/m<sup>2</sup> (1500 Btu/hr/ft<sup>2</sup>) in areas where emergency actions lasting several minutes may be required by personnel without shielding but with appropriate clothing
- 1.6 kW/m<sup>2</sup> (500 Btu/hr/ft<sup>2</sup>) at any location where personnel are continuously exposed
- temperature rating of electrical and mechanical equipment
- 50 % LEL at any point on the installation where the gas plume from a vent could be ignited or personnel could get into contact with the gas. The most unfavourable weather and process conditions have to be taken into consideration when calculating heat radiation and dispersion.

The limits above also apply to abnormal conditions (e.g. flame out of flare system and accidental ignition of vent).

## SECTION 4

### RISERS AND CRUDE EXPORT SYSTEMS

#### A. General

##### A 100 General

**101** The requirements in this section apply to rigid and flexible riser systems connecting the completed subsea well or subsea system to the piping installation on the unit for conveying hydrocarbons, injection of fluids and work over operations for wells.

**102** See DNV-OS-A101 for requirements for arrangement of risers and riser ESD valves.

**103** The riser ESD valve and associated actuator and controls shall be robust and protected from mechanical damage and accidental loads. They shall retain integrity for a sufficient period of time to isolate the flow of hydrocarbons in an emergency.

##### A 200 Recognised codes

**201** The rules, codes and standards listed in Table A1 are recognised for design and manufacture of riser systems.

Table A1 Recognised codes – Riser systems	
No.	Title
API RP 16Q	Design, Selection, Operation and Maintenance of Marine Drilling Riser Systems
API RP 17B	Flexible Pipe
API Spec 16R	Marine Drilling Riser Couplings
DNV-OS-F101	Submarine Pipeline Systems
DNV-OS-F201	Dynamic Risers
	Rules for Certification of Flexible Risers and Pipes

##### A 300 Riser disconnection systems (for floating installations)

**301** Emergency disconnection of flexible risers should be considered whenever permissible design limits are exceeded. The need for emergency disconnection shall be based on the outcome of a risk assessment that considers the likelihood of exceeding the design limits as well as the consequences of exceeding these limits.

**302** It shall be possible to activate the disconnection system from at least two independent locations, e.g. from turret or riser ESD valve area and from main control station. Consideration should be given to providing a manual back-up system for disconnection of risers (e.g. by hand pump) if the remote system fails.

**303** The riser and the release system shall be designed such that the pressure retaining capability of the riser is maintained, and the probability of damage to the riser or equipment on the sea floor is minimised, after release and during retrieval.

**304** No environmental damage shall be caused when the riser is disconnected. As a minimum, the end of the riser that is to be disconnected shall be fitted with a shut off valve. The shut off valve shall be closed before the riser can be disconnected.

**305** Failure of an element of the control system should not result in inadvertent release of the riser.

**306** It shall be possible to test important functions of the release system (e.g. closure of valve, release of connector etc.) without actually releasing the riser.

##### A 400 Monitoring and control

**401** The riser system shall be monitored from the main production plant control station.

**402** For floating installations, the control of unit movements relevant for operation of the riser system shall be performed from the main control station. Other positions may be considered for special arrangements.

**403** An alarm shall be raised before the operational limitations of the riser system are exceeded.

#### B. Pig Launchers and Receivers

##### B 100 General

**101** Pig launchers and receivers shall be fitted with double block and bleed valves that will isolate against sources of hydrocarbons when the door is opened.

**102** A system shall be provided to ensure that pig launchers and receivers are flushed and depressurised before the door can be opened.

**103** Pig launchers and receivers shall be fitted with a device that enables the operator to confirm that the vessel is completely depressurised before the door is opened (e.g. pressure gauge, pressure interlock, whistle etc.).

**104** Pig launchers and receivers shall be arranged with the centre-line oriented away from any critical equipment or structures.

**105** Bunds to collect spillage shall be provided below doors to pig launchers and receivers. The arrangement shall allow safe handling and storage of 'pigs' and deposits from the pipeline (e.g. wax or scale).

#### C. Crude Export Pump Systems

##### C 100 General

**101** Pump protection systems, set points and response times shall be designed to prevent damage to downstream pipelines and facilities.

**102** High capacity pipeline export and offloading pumps shall be fitted with a minimum flow bypass system to limit temperature rise in accordance with recommendations from the pump supplier.

**103** Non-return valves shall be installed downstream pumps to prevent backflow.

#### D. Crude Offloading System (for Floating Installations)

##### D 100 General

**101** The offloading system shall be designed so that single failures will not result in significant environmental or mechanical damage.

**102** The offloading system shall be designed and verified in accordance with relevant sections of this offshore standard, e.g. for piping, mechanical equipment, instrumentation etc.

**103** The offloading hose shall be designed to a recognised standard.

##### Guidance note:

OCIMF Guide to purchasing, manufacturing and testing of loading and discharge hoses for offshore moorings, Fourth Edition



1991 is a recognised standard. Note that the hose itself should be electrically continuous and isolated in the end connecting to the shuttle tanker and with electrical connection to the storage vessel. See ICS/OCIMF Ship to Ship Transfer Guide (Petroleum) Second Ed. Jan 88 Ch. 3.6.

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**104** The loading hose and hawser (where relevant) shall be arranged such that they cannot come in contact with the propellers on the unit or shuttle tanker during normal operations.

**105** Design limitations for the system shall be clearly stated, e.g. flow rate, design pressure, minimum hose bending radius, operational weather limitations, breaking loads etc.

**106** The hawser end connection shall, as a minimum, have a safety factor of 3 against failure. Stresses in hawser end connections shall not exceed 1.0 x yield stress or 0.8 x breaking strength when the system is subjected to design breaking load.

**107** Breakage points, weak links and release points shall be located and arranged such that personnel are not put in danger if the system breaks or is released unintentionally.

**108** The loading hose shall be fitted with fail safe isolation valve(s) that will close off flow automatically if the loading hose is disconnected or broken.

**109** The main piping arrangements for the offloading system shall be permanent. Loose sections of piping, which require to be re-coupled for loading operations, shall not be used.

**110** Facilities shall be provided to drain the offloading system including the loading hose.

**111** Bunds shall be provided for collection of possible leakage from loading hose end-connections during storage.

**112** Metal to metal contact during pull in or out of loading hose and hawser is to be avoided, e.g. by use of hardwood or other non-ignitable material at contact points.

**113** There shall be a control station for remote operation and monitoring of the offloading operation. This shall have direct view or indirect monitoring, e.g. by closed circuit TV, of relevant marine systems.

**114** The control station shall be located and protected with regard to relevant accidental events, e.g. hose rupture, fire, ingress of gas etc.

**Guidance note:**

This should preferably be achieved by locating the control station at a safe location. If this is impracticable, deluge systems, over-

pressure ventilation and enclosed escape routes may be alternative solutions.

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**115** The system shall have instrumentation enabling continuous measurement of the following parameters:

- offloading pressure (can be omitted if covered upstream)
- status of hose connection
- tension in connection equipment (e.g. hose winch).

**116** The control system shall have all necessary interlock functions as necessary to avoid spillage or other maloperations of the offloading system, (e.g. trip of system if hose connection is broken or start of cargo pump prior to connection of loading hose shall not be possible).

**117** The following functions shall be possible from the control station of the unit:

- control and monitoring of operations
- shutdown of offloading operations
- remote emergency release of connections located on the unit.

**118** The following functions shall be possible from the shuttle tanker:

- shutdown of offloading operations
- remote emergency release of connections
- manual emergency release of connections located on the shuttle tanker.

**119** The automatic release system shall be fail safe, with energy for actuated devices supplied from a local source. The manual release system shall be independent of the automatic system.

**120** Normal and emergency release shall not result in oil leakage, create ignition sources, or any other form of overloading or damage to the unit.

**121** Additional requirements for the automatic and manual release systems are given in Rules for Classification of Ships Pt.5 Ch.3 Sec.14, as applicable.

**122** The control station shall, as a minimum, have two independent systems for communication with other affected control stations, e.g. bridge and shuttle tanker.

## SECTION 5

# ELECTRICAL, INSTRUMENTATION AND CONTROL SYSTEMS

### A. Electrical Systems

#### A 100 Application

**101** The requirements regarding electrical systems shall be as required in the relevant DNV standard for electrical systems and equipment. In addition the requirements in this section apply.

**102** Other codes and standards such as IEEE, NFPA, IEC, BS or similar may be applied upon agreement in each case.

### B. Instrumentation and Control Systems

#### B 100 Application

**101** The requirements regarding instrumentation and control systems are given in DNV-OS-D202. In addition, the requirements in this section apply.

**102** Other codes and standards such as IEEE, API, IEC, BS or similar may be applied upon agreement in each case.

#### B 200 Scope

**201** This section gives requirements for the following essential systems:

- emergency shutdown system
- process shutdown and blowdown systems
- wellhead and subsea control system
- riser disconnection system
- fire and gas detection and alarm system
- high integrity protection systems (HIPS)
- protection systems for safety critical equipment trains (e.g. turbine or compressor skids).

**202** An *essential system* is defined DNV-OS-D202 as ‘....a system supporting equipment, which needs to be in continuous operation for maintaining the unit’s safety....’.

The definition is extended for systems associated with the hydrocarbon production plant to cover systems that are needed to be available on demand to prevent development of, or mitigate the effects of an undesirable event.

**203** This section gives requirements for the following important systems:

- process monitoring and control system
- monitoring and control safety critical systems (e.g. turbine or compressor skids).

**204** An *important system* is defined in DNV-OS-D202 as ‘....a system supporting equipment, which need not necessarily be in continuous operation, but which is required by the DNV Offshore Standards.

The definition is extended for systems associated with the hydrocarbon processing plant to cover systems which ensures reliable production and operation and which maintains plant operation within operational limitations.

### C. System Requirements

#### C 100 Clarification and amendments to system requirements in DNV-OS-D202

**101** The requirement for mutual independence of essential systems covered by this section is not absolute, as long as the reliability target is achieved. Systems with high reliability targets and where common mode failures can not be tolerated should however be independent, e.g. for high integrity protection systems.

**102** Essential systems shall have a power supply with built in redundancy with at least one UPS capable of maintaining the function of the system for sufficient time to monitor and control an emergency or a failure of A.C. power generation. The minimum duration is normally 3 hours.

**103** The systems, including central control units and field instrumentation shall be designed based on the ‘failure to safety’ principle. Failure of system components, controls or power supply shall result in the plant and equipment reverting to the least hazardous condition.

#### Guidance note:

This normally implies that control circuits are normally energised or pressurised, and de-energising will lead to automatic shutdown and depressuring or de-energising of the production plant.

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**104** Special cases where the traditional ‘failure to safety’ principle could lead to a more hazardous situation shall be evaluated in detail on a case by case basis.

#### Guidance note:

This could apply to e.g.:

- riser disconnection systems where spurious trips could result in environmental damage
- high level shutdown push buttons at the helicopter deck where damage from a helicopter incident could cause black-out and prevent emergency response.

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**105** The dew point of instrument air in open deck areas is to be – 40 °C or lower unless the unit or installation is not designed for operation at temperatures below 0 °C. In this case a maximum dew point of – 25 °C applies. See DNV-OS-D202.

## SECTION 6 PIPING

### A. General

#### A 100 Application

**101** The requirements in this section are applicable to piping for hydrocarbon production systems and corresponding utility systems. The piping includes pipes with bends, tees, crosses, reducers, weldolets, thredolets etc., flexible piping such as expansion elements and flexible hoses, valves and fittings, piping connections such as flanges with bolts and packings, welded connections, clamps and couplings, and pipe supports with hangers and brackets.

#### A 200 Recognised codes and standards

**201** Recognised codes for process piping design and installation are given in Table A1.

Table A1 Recognised codes for piping	
No.	Title
ANSI/ASME B31.3	Chemical Plant and Petroleum Refinery Piping
API RP 14E	Design and Installation of Offshore Production Platform Piping Systems
TBK 5-6	Generelle regler for rørsystemer. (General Rules for Piping Systems)
API RP 14C	Recommended Practice for Analysis, Design, Installation and Testing of Basic Surface Safety Systems for Offshore Production Platforms

**202** Recognised code for bellows and expansion joints is:

- EJMA, Standards of the Expansion Joint Manufacturer's Association Inc.

**203** Recognised codes for utility piping are:

- codes and standards listed in Table A1
- DNV-OS-D101
- Rules for Classification of Ships Pt.4 Ch.1.

### B. Design Requirements

#### B 100 General

**101** Relevant factors and combination of factors shall be taken into account during design when evaluating possible failure modes such as, but not limited to:

- corrosion or erosion types
- vibration, hydraulic hammer
- pressure pulsations
- abnormal temperature extremes
- impact forces
- leakages.

**102** Piping systems shall be properly segregated so that utility media, e.g. steam, compressed air cooling water etc., are not contaminated by flammable fluids.

**103** Piping flexibility analysis shall be performed when deemed necessary according to ANSI/ASME B31.3 or API RP 14 E.

**104** External and internal attachments to piping shall be designed so that they will not cause flattening of the pipe, excessive local bending stresses, or harmful thermal gradients in the

pipe wall. Constructions causing stress concentrations shall be minimised, particularly in cyclic service applications.

**105** Line pockets shall be avoided as far as possible in all piping systems, and in particular in the following:

- blowdown and relief valve discharge lines
- compressor suction lines
- lines where water can accumulate and freeze
- lines carrying caustic or acidic fluids, or other fluids that may freeze
- lines which contain solids which may settle out
- piping in which corrosive condensate may form.

All equipment piping should be arranged to provide sufficient clearances for operation, inspection, maintenance and dismantling with the minimum interference or removal of piping or equipment. Attention should be paid to clearances required for removal of equipment such as pumps, pump drivers, exchanger bundles etc.

**106** All pipe runs shall be clearly identified by colour codes or by other acceptable means.

#### B 200 Wall thickness

**201** The minimum design wall thickness of piping is to account for strength thickness and:

- bending allowances
- allowances for threads
- corrosion allowances
- erosion allowances
- negative manufacturing tolerance.

**202** The strength thickness ( $t_p$ ) shall be calculated according to one of the reference codes given in A200.

**203** Calculation for the reinforcement is needed when weldolets of unrecognised type and shape are used in a branch connection.

#### B 300 Expansion joints and flexible hoses

**301** The locations of expansion joints and flexible hoses shall be clearly shown in the design documentation.

**302** Piping in which expansion joints or bellows are fitted shall be adequately adjusted, aligned and clamped. Protection of the expansion joint or bellow against mechanical damage may be required if found necessary.

**303** Expansion joints and flexible piping elements shall be accessible for inspection.

**304** The bursting pressure for flexible hoses shall be at least 4 times the maximum working pressure. High pressure hoses with large nominal bores are subject to special consideration. In no case, however, is the bursting pressure to be taken as less than two times the maximum working pressure.

**305** Means shall be provided to isolate flexible piping if used in systems where uncontrolled outflow of medium is critical.

**306** Flexible hoses and non-metallic expansion joints for flammable fluids systems have to qualify a fire endurance test according to Classification Note No. 6.1 (test method B) or equivalent. The flexible hose has to maintain its integrity and functional properties for the same period as required for the total piping system and components.

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

## **B 400 Valves and special items**

**401** See also functional requirements for valves given in Sec.1.

**402** Screwed-on valve bonnets are not to be used for valves with nominal diameter exceeding 50 mm.

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

**404** Weld necks of valve bodies shall be of sufficient length in order to ensure that the valve internals are not distorted due to heat from welding and subsequent heat treatment of the joints.

## **B 500 Piping connections**

**501** The number of detachable pipe connections shall be limited to those that are necessary for mounting and dismantling. The piping connections shall be in accordance with the applied code or standard.

**502** Joints of pipes with outer diameter of 51 mm and above are normally to be made by butt welding, flanged or screwed union where the threads are not part of the sealing. Joints for smaller sizes may be welded or screwed and seal welded if not intended for corrosive fluids. Tapered threads and double bite or compression joints may be accepted.

**503** If the piping system is rated for 207 bar (3000 psi) or more, ordinary threaded connections shall not be used.

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

**505** Tapered threads shall be used on couplings with stud ends where such couplings are permitted.

**506** Calculations of the reinforcement are required when:

- weldolets of unrecognised type and shape are used in the branch connection

- the strength is not provided inherently in the components in the branch connection.

### **Guidance note:**

ANSI/ASME B 31.3, 304.3 may be referred to.

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## **B 600 Supporting elements**

**601** Piping shall be supported in such a way that its weight is not taken by connected machinery or that heavy valves and fittings do not cause large additional stresses in adjacent pipes.

**602** Axial forces due to internal pressure, change in direction or cross-sectional area shall be taken into consideration when mounting the piping.

**603** The support of the piping shall be such that detrimental vibrations will not arise in the system.

**604** Attachments welded directly to pipes shall not be used on piping rated 207 bar (3000 psi) or above. Gland type (stuffing box) penetrations shall be applied for pipe penetrations through decks or bulkheads.

**605** Attachments welded directly to pipes rated below 207 bar (3000 psi) shall be avoided. Where this cannot be avoided, doubling plates shall be used, or the support shall, by other means, be welded to the pipe in a way that introduces the minimum of stresses to the pipe surface from forces acting on the support.

**606** Pipes and their supports shall be installed with sufficient flexibility so they do not take up hull forces caused by the unit's movements and temperature variations.

### **Guidance note:**

The expansion or compression possibility should for pipes along the main deck of a steel ship be at least  $\pm 10$  mm for every 10 m section length from the fixed point.

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## SECTION 7 EQUIPMENT

### A. General

#### A 100 Application

**101** The requirements in this section are applicable to mechanical equipment in general. Specific references have been given for the following equipment:

- unfired pressure vessels
- boilers
- atmospheric tanks
- heat exchangers
- pumps
- compressors
- combustion engines
- gas turbines
- shafts, gears and couplings
- wellhead equipment
- lifting appliances.

**102** Equipment used in production plants or otherwise related to safety in conjunction with production, shall be designed, manufactured, installed and tested in accordance with recognised codes, standards or guidelines, as given in B.

**103** Requirements for equipment which have not been covered by specific references shall be agreed between parties involved on a case by case basis. Where possible, internationally accepted codes and standards in addition to the general requirements given elsewhere in DNV Offshore Standards.

### B. Recognised Codes and Standards

#### B 100 Unfired pressure vessels

**101** Recognised codes for unfired pressure vessels are listed in Table B1.

Table B1 Recognised codes for unfired pressure vessels	
Code	Title
ASME	Boiler and Pressure Vessels Code, Section VIII, Pressure Vessels
BSI PD 5500	Specification for unfired fusion welded pressure vessels
Rules for Classification of Ships Pt.4 Ch.3	Boilers, pressure vessels, thermal-oil installations and incinerators

#### B 200 Boilers

**201** Recognised codes for boilers are given in Table B2.

Table B2 Recognised codes for boilers	
Code	Title
API Std 530	Calculation of Heater Tube Thickness in Petroleum Refineries
ASME	Boiler and Pressure Vessel Code, Section I, Power Boilers
ASME	Boiler and Pressure Vessel Code, Section IV, Rules for Construction of Heating Boilers
BS 1113	Specification for design and manufacture of water-tube steam generating plant
BS 2790	Specification for design and manufacture of shell boilers of welded construction
BSI PD 5500	Specification for unfired fusion welded pressure vessels
Rules for Classification of Ships Pt.4 Ch.3	Boilers, pressure vessels, thermal-oil installations and incinerators
ISO/R 831	Rules for construction of stationary boilers
TBK 1 - 2	Generelle regler for trykkbeholdere. (General rules for pressure vessels) should be used together with Regulation of 11 February 1993 of boiler plant. (Issued by the Norwegian Directorate for fire and explosion prevention (DBE))

#### B 300 Atmospheric vessels

**301** Table B3 Recognised codes for atmospheric vessels are given in .

Table B3 Recognised codes for atmospheric vessels	
Code	Title
API Spec 12 F	Shop Welded Tanks for Storage of Production Liquids
API Std 650	Welded Steel Tanks for Oil Storage
BS 2654	Manufacture of vertical steel welded non-refrigerated storage tanks with butt-welded shells for the petroleum industry
DIN 4119	Above-ground Cylindrical Flat-bottomed Tank Installations of Metallic Materials

#### B 400 Heat exchangers

**401** Recognised codes for heat exchangers are given in Table B4.

Table B4 Recognised codes for heat exchangers	
Code	Title
API Std 661	Air-Cooled Heat Exchangers for General Refinery Service
Rules for Classification of Ships Pt.4 Ch.3	Boilers, pressure vessels, thermal-oil installations and incinerators
TEMA	Standards for Heat exchangers
-	Pressure vessel codes given in Table B1

#### B 500 Pumps

**501** Recognised codes for pumps are given in Table B5.

Table B5 Recognised codes for pumps	
Code	Title
ASME/ANSI B73.1	Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process
ASME/ANSI B73.2	Specification for Vertical In-line Centrifugal Pumps for Chemical Process

API Std 610	Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services
API Std 674	Positive Displacement Pumps - Reciprocating
API Std 675	Positive Displacement Pumps - Controlled Volume
API Std 676	Positive Displacement Pumps - Rotary
Rules for Classification of Ships Pt.4 Ch.1	Machinery and System Design, General

## B 600 Compressors

**601** Recognised codes for compressors are given in Table B6.

Table B6 Recognised codes for compressors	
Code	Title
API Std 617	Centrifugal Compressors for Petroleum, Chemical and Gas Industry Services
API Std 618	Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services
API Std 619	Rotary-Type Positive Displacement Compressors for Petroleum, Chemical and Gas Industry Services
API Std 672	Packaged, Integrally Geared Centrifugal Air Compressors for Petroleum, Chemical, and Gas Industry Services
Rules for Classification of Ships Pt.4 Ch.2	Propulsion and Auxiliary Machinery

## B 700 Combustion engines

**701** Recognised codes for combustion engines are given in Table B7.

Table B7 Recognised codes for combustion engines	
Code	Title
EEMUA publication 107	Recommendations for the Protection of Diesel Engines for Use in Zone 2 Hazardous Areas
ISO 3046-1	Reciprocating internal combustion engines - Part 1 - Performance
NFPA 37	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
Rules for Classification of Ships Pt.4 Ch.2	Propulsion and Auxiliary Machinery

## B 800 Gas turbines

**801** Recognised codes for gas turbines are given in Table B8.

Table B8 Recognised codes for gas turbines	
Code	Title
API Std 616	Gas Turbines for the Petroleum, Chemical and Gas Industry Services
ASME/ANSI B133.4	Gas Turbine Control and Protection Systems
ISO 2314	Gas turbine - Acceptance tests
ASME PTC 22	Performance Test Code on Gas Turbines (Performance Test Codes)
NFPA 37	Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
Rules for Classification of Ships Pt.4 Ch.2	Propulsion and Auxiliary Machinery

## B 900 Shafting

**901** Recognised codes for shafting are given in Table B9.

Table B9 Recognised codes for shafting	
Code	Title
Rules for Classification of Ships Pt.4 Ch.2	Propulsion and Auxiliary Machinery

## B 1000 Gears

**1001** Recognised codes for gears are given in Table B10.

Table B10 Recognised codes for gears	
Code	Title
ANSI/AGMA	Standard for Marine Gear Units: Rating
API Std 613	Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services
ISO 6336 Pt. 1-5	Calculation of load capacity of spur and helical gears
Classification Note 41.2	Calculation of Gear Rating for Marine Transmissions
Rules for Classification of Ships Pt.4 Ch.2	Propulsion and Auxiliary Machinery

## B 1100 Couplings

**1101** Recognised codes for couplings are given in Table B11.

Table B11 Recognised codes for couplings	
Code	Title
API Std 671	Special Purpose Couplings for Petroleum, Chemical and Gas Industry Services
Rules for Classification of Ships Pt.4 Ch.2	Propulsion and Auxiliary Machinery

## B 1200 Lubrication and sealing

**1201** Recognised codes for lubrication and sealing are given in Table B12.

Table B12 Recognised codes for lubrication and sealing	
Code	Title
API Std 614	Lubrication, Shaft-Sealing and Control-Oil Systems and Auxiliaries for Petroleum, Chemical and Gas Industry Services

## B 1300 Wellhead equipment

**1301** Recognised codes for wellhead equipment are given in Table B13.

<b>Table B13 Recognised codes for wellhead equipment</b>	
<i>Code</i>	<i>Title</i>
API Spec 6A	Wellhead and Christmas Tree Equipment
API Spec 6FA	Fire Test for Valves
API Spec 6FC	Fire Test for Valve With Automatic Backseats
API Spec 6FD	Fire Test for Check Valves
API RP 14B	Design, Installation, Repair and Operation of Sub-surface Safety Valve Systems
API RP 14H	Installation, Maintenance and Repair of Surface Safety Valves and Underwater Safety Valves Off-shore
ISO 10433	Petroleum and Natural Gas Industries - Drilling and Production Equipment - Specification for Wellhead Surface Safety Valves and Underwater Safety Valves for Offshore Service (Based on API Spec 14D)

## **B 1400 Lifting appliances**

**1401** Recognised codes for lifting appliances are given in Table B14.

<b>Table B14 Recognised codes for lifting appliances</b>	
<i>Code</i>	<i>Title</i>
API Spec 2C	Offshore Cranes
	Rules for Certification of Lifting Appliances

## SECTION 8 STRUCTURES

### A. General

#### A 100 Application

**101** The requirements in this section apply to:

- support structures and skids for production facilities
- base frames for production equipment
- flare and vent structures
- conductor and riser supports
- pipe racks and general pipe supports.

#### A 200 Recognised codes and standards

**201** Structures shall be designed and fabricated in accordance with recognised international codes as listed in Table A1.

Table A1 Recognised codes for structures	
Code	Title
AISC LRFD	Manual of Steel Construction
AISC ASD	Manual of Steel Construction
API RP 2A - LRFD with supplement 1	Planning, Designing and Constructing Fixed Offshore Platforms - Load and Resistance Factor Design
API RP 2A - WSD with supplement 1	Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design
BS 5950	Structural use of steelwork in building
DNV-OS-C101	Design of Offshore Steel Structures, General (LR-FD method)
NS 3471	Prosjektering av aluminiumskonstruksjoner - Beregning og dimensjonering (Aluminium structures - Design rules)
NS 3472	Steel structures - Design rules

**202** Other recognised codes may be applied in lieu of those listed provided that an equivalent safety level is maintained.

### B. Design Requirements

#### B 100 General

**101** Structures shall be categorised in accordance with their importance for overall safety of the unit or installation. The

categorisation in Table B1 applies for the structures covered by this section.

Table B1 Categorisation of structures	
Description	Category <sup>1)</sup>
Main structural elements and load transfer points in large support structures, modules or skids	Primary
Base frames for equipment	Secondary
Flare or ventilation structures	Primary <sup>2)</sup>
Support for flare structure	Special <sup>2), 3)</sup>
Supports for conductors and risers	Special <sup>3)</sup>
Pipe racks and pipe supports	Secondary
<p>1) The various categories are defined in DNV-OS-C101.</p> <p>2) The categorisation applies to flare or ventilation towers and booms. Ground flares may, based on a consideration of criticality be given a lower categorisation.</p> <p>3) The categorisation applies to highly utilised elements or elements, which are not redundant and which could lead to loss of integrity or pressure containment on failure. Categorisation can be reduced for elements falling outside this definition by evaluation of criticality.</p>	

**102** Permanent lifting points, runway beams etc. attached to structures shall be designed in accordance with the Rules for Certification of Lifting Appliances or an equivalent recognised code.

**103** Flare structures shall be designed with due consideration to loads from wind, unit motions, thermal loads from the flare and possible contraction of the flare pipe caused by discharge of low temperature gas.

### C. Manufacture and Testing

#### C 100 General

**101** Manufacture and testing shall be in accordance with relevant parts of the applied code and the requirements given in Sec.10.



## SECTION 9 MATERIALS AND CORROSION PROTECTION

### A. General

#### A 100 Objective

**101** This section provides requirements for materials and corrosion protection applicable to hydrocarbon production systems and associated structures.

### B. Principles

#### B 100 General

**101** Selection of materials shall be based on type and level of stresses, temperatures, corrosive and erosive conditions, consequences and possibilities of failure associated with installation, operation and maintenance.

**102** The materials selected shall be suitable for the purpose and have adequate properties of strength and ductility. Materials incorporated in any portion of a system which are critical to the integrity and safety shall have good weldability properties for manufacture and installation, if welding shall be performed. Materials shall be corrosion resistant or protected against corrosion where this is deemed necessary.

**103** Non-combustible materials shall be used. Where any required property does not permit the use of such material, alternative materials may be used subject to agreement.

**104** For selection of acceptable materials suitable for H<sub>2</sub>S contaminated products (sour service), see ANSI/NACE MR0175.

### C. Specific Requirements

#### C 100 Materials for pressure vessels, piping and equipment

**101** Materials for equipment and piping shall be in accordance with the requirements given by the referred recognised codes.

#### C 200 Materials for load-carrying parts

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

—  $C \leq 0.22 \%$

—  $CE_a = C + \frac{Mn}{6} + 0.04 \leq 0.45 C \%$

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

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

**202** Materials not meeting this limitation may be used subject to suitable welding procedures in each case. The welding of such materials normally requires more stringent fabrication procedures regarding selection of consumables, preheating and post weld heat treatment, see Sec.10.

**203** Impact testing is required for steel materials with reference thickness above 6 mm, if the minimum design temperature (MDT) is below 0 °C. These materials shall meet Charpy

V-notch energy values of minimum 34 J at MDT. For test procedures and requirements, see DNV-OS-B101.

**204** If equipment is required to be designed against sulphide stress corrosion cracking, the hardness of any part of material and welds for ferritic steels is not to exceed 260 HV<sub>5</sub> in the final heat treated condition. For other steel materials, see ANSI/NACE MR0175, concerning allowable hardness.

**205** Plates that transfer significant loads in the thickness direction of the plate shall be documented with through thickness ductility in order to reduce the probability of lamellar tearing. The minimum reduction of area,  $Z_z$ , is not to be less than 25 %.

#### C 300 Rolled steel

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

#### C 400 Steel forgings

**401** The material standard or specification has to define an extent of testing comparable to that described DNV-OS-B101.

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

#### C 500 Steel and iron castings

**501** The material standard or specification shall define an extent of testing comparable to that described DNV-OS-B101.

**502** Iron castings shall not to be used for critical parts with minimum design temperature below 0 °C.

#### C 600 Aluminium, copper and other non-ferrous alloys

**601** Aluminium, copper and other non-ferrous alloys shall have a supply condition, chemical composition, mechanical properties, weldability and soundness as described in DNV-OS-B101.

Other standards giving comparable parameters may be used upon special agreement.

#### C 700 Bolts and nuts

**701** Bolts and nuts considered as essential for structural and operational safety shall conform to a recognised standard, e.g. ISO 898.

**702** Major pressure retaining or structural bolts and nuts with specified minimum yield stress above 490 N/mm<sup>2</sup> shall be made of alloy steel, i.e. (% Cr + % Mo + % Ni) = 0.50 and supplied in the quenched and tempered condition.

**703** For general service, the specified tensile properties are not to exceed ISO 898 property Class 10.9 when the installation is in atmospheric environment. For equipment submerged in seawater, the tensile properties are not to exceed property class 8.8 or equivalent.

#### Guidance note:

For bolted joints to be part of equipment designed for sulphide stress cracking service, lower tensile properties than for 8.8 class may be necessary in order to comply with ANSI/NACE MR0175.

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## C 800 Sealing materials and polymers

**801** The materials to be used shall be suitable for the intended service and are to be capable of sustaining the specified operating pressure and temperature of the particular unit or fluid.

## D. Material Certificates

### D 100 General

**101** All materials for major load-bearing and pressure containing components and load carrying parts shall be furnished with documentation stating process of manufacture and heat treatment (metallic materials) together with results of relevant properties obtained through appropriate tests carried out in accordance with recognised standards.

#### Guidance note:

The following mechanical properties should normally be tested and recorded on a material certificate:

- ultimate tensile strength and yield strength
- elongation and reduction of area
- Charpy V-notch impact toughness
- hardness, where applicable e.g. for sour service
- through thickness properties, where applicable.

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### D 200 Type of document

**201** Material certificate types shall be as given in Table D1.

**202** Test certificate shall be required for:

- plates for boilers and steam heated equipment
- plates for pressure vessels with thickness  $t > 38$  mm
- cast iron and cast steel for use at temperature  $T > 400$  °C or  $pD > 2000$  where  $p$  = pressure in bar,  $D$  = diameter in mm.

**203** Works certificate shall be required for:

- materials for pressure containing and major load carrying components which are not included in 202.

**204** Test report shall be acceptable for other equipment.

Table D1 Material certification	
<i>Certification process</i>	<i>ISO 10474 (EN 10204)</i>
<i>Test report</i> Confirmation by the manufacturer that the supplied products fulfil the purchase specification, and test data from regular production, not necessarily from products supplied	2.2
<i>Work certificate</i> Test results of all specified tests from samples taken from the products supplied. Inspection and tests witnessed and signed by QA department	3.1.B
<i>Test certificate</i> As work certificate, inspection and tests witnessed and signed by an independent third party body	3.1.C

## E. Corrosion Protection

### E 100 General

**101** Equipment and piping shall be corrosion resistant or protected against corrosion where considered necessary for safety or operational reasons.

#### Guidance note:

Unprotected carbon steel and stainless steel materials are not to be used for seawater service except for high molybdenum stainless steel or equivalent.

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Corrosion allowance of low alloy carbon steel shall be dependent on corrosivity of commodity, lifetime of equipment and corrosion control method used.

#### Guidance note:

Corrosion allowance in Table E1 is given as guidance.

Table E1 Corrosion allowance “c” for steel materials	
<i>Service</i> <sup>1) 2)</sup>	<i>c (mm)</i>
Saturated steam	0.8
Steam coils	2
Feedwater and blowdown pipes (for boilers)	1.5
Compressed air	1.0
Hydraulic oil	0.3
Lubricating oil	0.3
Fuel oil	1
Refrigerants	0.3
Fresh water	0.8
Hydrocarbon service	2
Mud or cement	3
1) An additional allowance for external corrosion shall be considered according to the figures given in the Table, depending on the external medium	
2) Where efficient protective methods against corrosion are used, the corrosion allowance may be reduced up to 50 %	

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**102** Dissimilar metallic materials in contact shall be avoided or adequately protected against galvanic corrosion.

**103** External steel surfaces exposed to the marine atmosphere and splash zone shall be protected by coating. Special metallic materials may be used.

**104** Steel components submerged in seawater shall be externally protected by cathodic protection or a combination of cathodic protection and coating.

**105** Internal corrosion control shall be used if the commodity contains water or has a relative humidity, of more than 50 % and if the partial pressure of corrosive gases is above the following limits:

- oxygen: 100 Pa
- hydrogen sulphide: 10 kPa
- carbon dioxide: 20 kPa

Increased corrosivity due to combination of gases shall be considered.

**106** Inhibitors shall be selected when relevant to suit the actual internal environment.

**107** Corrosion monitoring shall be used where considered necessary.

## F. Erosion

### F 100 General

**101** Precautions shall be taken to monitor and avoid erosion in process piping and equipment.

## SECTION 10 MANUFACTURE, WORKMANSHIP AND TESTING

### A. General

#### A 100 Application

**101** This section covers equipment, structures and systems during fabrication, installation and final testing onboard.

#### A 200 Quality assurance and quality control

**201** The manufacturer shall have the necessary production facilities, qualifications, procedures and personnel to ensure that the product will be manufactured to the specified requirements.

#### A 300 Marking

**301** All equipment shall be clearly marked with identification and serial number, relating the equipment to certificates and fabrication documentation.

##### Guidance note:

Low stress stamping may be required for certain materials. Paint markings may be acceptable, but care must be exercised during handling and storage to preserve the identification.

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### B. Manufacture

#### B 100 Welder's qualification

**101** Welding of pressure containing components and piping systems and welding of load carrying equipment and structures shall be carried out by certified welders, only.

**102** The manufacturer shall supply each welder with an identification number or symbol to enable identification of the work carried out by each particular welder.

#### B 200 Welding

**201** All welding as specified in 101 shall be performed in accordance with an approved welding procedure specification (WPS).

**202** A welding procedure qualification test (WPQT) may be required when makers intend to use welding procedure specification (WPS) for which there exists insufficient experience at plant or elsewhere or if new complicated structural details are used. For details of performance of WPQT, limitations etc. see DNV-OS-C401 or the applied design and fabrication code.

**203** Butt welded joints shall be of the full penetration type.

**204** If supports and similar non-pressure parts are welded directly to pressure retaining parts, the welding requirements for the pressure retaining parts shall be adhered to.

**205** Repair welding is normally to be carried out with electrodes giving a weld deposit compatible with the parent material.

#### B 300 Heat treatment

**301** The component shall be heat treated after forming and/or welding if required by the applied code or standard or if found necessary to maintain adequate notch ductility and to avoid hydrogen induced cracking.

**302** Rate of heating and cooling, hold time and metal temperature shall be properly recorded.

**303** A normalising heat treatment is required for hot-formed parts, unless the process of hot forming has been carried out

within the appropriate temperature range, duration and cooling rate.

**304** The heat treatment for cold-worked materials shall be selected with respect to the degree of plastic deformation in the material.

**305** Preheating and/or post weld heat treatment shall be used when necessitated by the dimensions and material composition.

**306** Post weld heat treatment (PWHT) is normally to be performed in a fully enclosed furnace. Local PWHT may be performed on simple joints when following an approved procedure.

**307** In case of defects being revealed after heat treatment, new heat treatment shall normally be carried out after repair welding of the defects.

#### B 400 Pipe bending

**401** The bending procedure shall be such that the flattening of the pipe cross section and wall thinning are within acceptable tolerances specified in the applied code and standard.

### C. Non-destructive Testing (NDT)

#### C 100 General

**101** The extent of NDT shall be in accordance with the code or standard accepted for design and fabrication, except as specified in 102.

**102** The minimum extent of NDT shall be in accordance with the requirements given in Table C1.

**Table C1 Extent of non-destructive testing of welds for pressure containing components and piping**

Limitations	Weld type <sup>4)</sup>	Visual inspection, see 106	Radiography, see 104	Magnetic particle, see 105
up to 150# rating and 185 °C <sup>1)</sup>	L	100 %	10 %	10 %
	C	100 %	5 %	5 %
	B	100 %	-	10 %
300# rating <sup>2)</sup>	L	100 %	20 %	20 %
	C	100 %	10 %	10 %
	B	100 %	-	100 %
over 300# rating <sup>3)</sup>	L	100 %	100 %	100 %
	C	100 %	100 %	100 %
	B	100 %	-	100 %

1) Piping and components for non-flammable, non-toxic utility service. Pressure rating up to 150 lbs (PN 20). Upper temperature limit 185 °C

2) Process and utility piping up to pressure rating 300 lbs (PN 50)

3) Process and utility piping with pressure rating above 300 lbs (PN 50) or subject to severe cyclic loading. (See ANSI B31.3 para. 300.2 for definition of severe cyclic loading)

4) L = Longitudinal weld, including intersection between L and C  
C = Circumferential, stub-in or butt weld  
B = Fillet weld e.g. for outlets, reinforcement rings etc.

**103** The acceptance criteria shall be in accordance with the code or standard accepted for design and fabrication.

**104** Ultrasonic examination may be used in lieu of radiography where practicable and where radiography does not give definitive results.

**105** Magnetic particle inspection is the preferred method for detection of surface defects. For non-magnetic materials, liquid penetrant method shall be used.

**106** Visual inspection of fabricated components, spools etc. shall cover both fabrication, welding, erection and assembly. The inspection points to be covered during fabrication, erection and assembly shall be defined in the client's procedures and shall be sufficiently extensive to ensure that code requirements and design intent are incorporated during fabrication e.g. fit-up, flange alignment, welding parameters, weld profile, supports and bolt tightening.

**107** NDT required by Table C1 shall be carried out in accordance with recognised NDT standards, by qualified operators.

**108** When post weld heat treatment is required, the final NDT should normally be performed after heat treatment.

**109** The final NDT shall be performed before any possible process that would make the required NDT impossible or would have erroneous results as a consequence (e.g. coating of surfaces).

**110** All performed examination and results shall be recorded in a systematic way allowing traceability.

**111** In addition to above, if the carbon equivalent, see Sec.9 C200, exceeds 0.45 for the actual material, a 100 % magnetic particle examination shall be carried out during the initial phase of production to prove absence of surface cracks.

## **C 200 Structures**

**201** Non-destructive testing of structures shall be in accordance with relevant parts of the applied code, see Sec.8 and this section.

## **D. Testing**

### **D 100 Testing of weld samples**

**101** Mechanical testing of weldments shall be carried out by competent personnel and in accordance with the applied code or standard.

**102** Weldments of piping and equipment used for H<sub>2</sub>S contaminated fluids shall be tested for hardness in accordance with ANSI/NACE MR0175.

### **D 200 Pressure testing and cleaning**

**201** Pressure containing piping and components shall be subject to a hydrostatic pressure test in accordance with applied codes and standards.

**202** The test pressure shall be determined by the working pressure, and shall minimum be 1.5 x the maximum working pressure if not otherwise specified in the applied codes or standards.

**203** The holding time shall be minimum 15 minutes, or as defined in the applied codes or standards. The time must be of sufficient length to allow for thorough visual examination when the pressure has stabilised.

**204** The pressure and holding time shall be recorded and documented in a systematic way allowing traceability, e.g. with a calibrated chart recorder.

**205** If hydrostatic pressure testing of piping represents particular problems, alternative methods of testing may be applied.

**206** Nominal stresses are in no case to exceed 90 % of the minimum specified yield strength of the material.

**207** Piping systems shall be cleaned (e.g. by flushing, retro-jetting, chemical cleaning etc.) to remove debris or foreign bodies prior to start-up of sensitive equipment such as pumps, compressors, isolation valves etc.

### **D 300 Load testing**

**301** Lifting appliances rated below 20 tonnes shall be load tested after installation onboard with 25 % in excess of the safe working load (SWL), in accordance with a written test program.

**302** Flare booms for well testing and work-over shall be tested after installation with an overload of 25 % related to the required weight of burner and spreader. This overload test is to demonstrate that the boom is capable of carrying out the motions such as slewing, hoisting etc., as relevant.

### **D 400 Functional testing**

**401** All systems, including associated control, monitoring and safety systems shall be tested as far as possible prior to introduction of hydrocarbons.

#### **Guidance note:**

The objective is to prove the functionality of all systems required for safe commissioning of the plant.

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**402** Tests shall as a minimum include adjustment of controllers, calibration of sensors and alarms, function and timing of shutdown and blowdown valves and function testing of protection systems.

**403** Testing of protection systems for process and utility systems and for safety critical equipment shall be in accordance with written test programmes.

**404** The status of tests shall be recorded in an auditable manner and a system to control status of remedial and outstanding work shall be established.

**405** Tests shall simulate operating conditions as far as practicable and shall cover all levels of shutdowns.

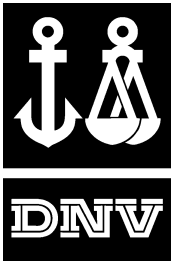
**406** Shortly after introduction of hydrocarbons, a final test programme shall be carried out where the functionality of essential elements of protection systems is proven under operating conditions.

#### **Guidance note:**

The final 'hot test' will typically take place 2 to 4 weeks after start-up of production, after the production plant has been commissioned.

It should cover any tests that were not possible to carry out prior to introduction of hydrocarbons, e.g. function test of de-pressuring system. It will also cover the various staged shutdown levels and include timing of shutdown valves.

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CHAPTER 3

## CERTIFICATION AND CLASSIFICATION

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## SECTION 1 CERTIFICATION AND CLASSIFICATION

### A. General

#### A 100 Introduction

**101** As well as representing DNV's interpretation of safe engineering practice for general use by the offshore industry, the offshore standards also provide the technical basis for DNV classification, certification and verification services.

**102** A complete description of principles, procedures, applicable class notations and technical basis for offshore classification is given by the offshore service specifications, see Table A1.

**Table A1 Offshore Service Specifications**

<i>No.</i>	<i>Title</i>
DNV-OSS-101	Rules for Classification of Drilling and Support Units
DNV-OSS-102	Rules for Classification of Floating Production and Storage Units

**103** Classification procedures and requirements specifically applicable in relation to the technical provisions in Ch.2 are given in Ch.3 of this standard.

**104** DNV may accept alternative solutions found to represent an overall safety level equivalent to that stated in the requirements of this standard.

#### A 200 Class designation

**201** Offshore units and installations fitted with hydrocarbon production plants that have been designed, constructed and installed in accordance with the requirements of this standard under the supervision of DNV will be entitled to the class notation **PROD**.

**202** DNV may accept decisions by national authorities as basis for assigning class.

#### A 300 Assumptions

**301** Any deviations, exceptions and modifications to the design codes and standards given as recognised reference codes shall be documented and approved by DNV.

**302** Where codes and standards call for the extent of critical inspections and tests to be agreed between contractor or manufacturer and client, the resulting extent is to be agreed with DNV.

## SECTION 2 DESIGN REVIEW

### A. General

#### A 100 Application

**101** This section lists design related requirements for certification or classification.

### B. Specific Requirements for Certification or Classification

#### B 100 General

**101** The following requirements shall be applied in conjunction with the technical requirements in Ch.2 of this standard when used for certification or classification purposes.

#### B 200 Design principles

**201** Ch.2 Sec.1:

- 1) Structures, equipment and systems outside the boundaries stated in Sec.1 A100, such as wellhead equipment, buoys with riser connections to seabed and export lines for crude oil and gas may be covered to the extent and according to rules and/or standards specified in the agreement for classification.
- 2) If requirements of applicable governmental regulations are incompatible with the requirements of this standard, the regulations will take precedence.

#### B 300 Electrical, instrumentation and control systems

**301** Ch.2 Sec.5:

- 1) Other codes and standards such as IEEE, API, IEC, BS or similar may be applied upon consideration in each case.

##### Guidance note:

Such agreement may be given if it is demonstrated that implications for personnel and plant safety are insignificant. The client is to forward a detailed application where the systems affected are listed and where deviations between the various codes are identified. Any implications for personnel and plant safety, operation and maintenance shall be evaluated.

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- 2) The failure mode shall be agreed with DNV on a case by case basis.

#### B 400 Piping

**401** Ch.2 Sec.6:

- 1) Piping parts that are covered by recognised standards and have a complicated configuration that makes theoretical calculations unreliable may be accepted based on certified prototype proof test reports. Prototype test methods and acceptance criteria shall be agreed with DNV.

- 2) Not welded valves designed, fabricated and tested according to recognised standards will be accepted based on the manufacturer's certification.
- 3) Special valves constructed by welding and of 600 lbs (PN 100) flange rating and above are subjected to design verification and inspection.
- 4) Special items not covered by recognised standards shall be approved for their intended use. Drawings shall be submitted for approval and shall be supported by stress calculations. Application, type of medium, design pressure, temperature range, materials and other design parameters shall be given.
- 5) Special items not covered by recognised standards having a complicated configuration that makes theoretical calculations unreliable may be accepted based on certified prototype proof test reports that prove their suitability for the intended use.

#### B 500 Materials and corrosion protection

**501** Ch.2 Sec.9:

- 1) B103: The use of alternative materials shall be approved by DNV.
- 2) C202: Modified material compositions and properties shall be documented in specifically written specifications that shall be submitted for approval in each case.
- 3) C402: Position and orientation of steel forging test samples shall be agreed with DNV.
- 4) C601: Alternative standards for aluminium, copper and non-ferrous alloys shall be agreed with DNV.

#### B 600 Manufacture, workmanship and testing

**601** Ch.2 Sec.10:

- 1) Welding repairs shall be performed according to an approved repair procedure.
- 2) If the required NDT reveals a defect requiring repair, additional testing shall be carried out at the discretion of the surveyor in accordance with the applied code or standard.
- 3) Testing of protection systems for process and utility systems and for safety critical equipment shall be in accordance with written test programmes accepted by DNV.
- 4) Shortly after introduction of hydrocarbons, a final test programme shall be carried out where the functionality of essential elements of protection systems is proven under operating conditions. The programme shall be accepted by DNV.

### C. Documentation Requirements

#### C 100 General

**101** Documentation on design and fabrication shall be in accordance with DNV-RP-A201 and DNV-RP-A202.



## SECTION 3 CERTIFICATION OF EQUIPMENT

### A. General

#### A 100 General

**101** Equipment shall be certified consistent with its functions and importance for safety.

**102** Equipment referred to in this standard will be categorised as follows:

##### Category I:

- Equipment related to safety for which a DNV certificate is required.
- Category I equipment is subdivided into IA and IB categorisation.

##### Category II:

- Equipment related to safety for which a works certificate prepared by the manufacturer is accepted.

**103** For equipment category I, the following approval procedure shall be followed:

- Design approval, followed by a design verification report (DVR) or type approval certificate.
- Fabrication survey followed by issuance of a product certificate.

**104** Depending on the required extent of survey, category I equipment is subdivided into IA and IB with the specified requirements as given below.

##### Guidance note:

It should be noted that the scopes defined for category IA and IB are typical and adjustments may be required based on considerations such as:

- complexity and size of a delivery
- previous experience with equipment type
- maturity and effectiveness of manufacturer's quality assurance system
- degree of subcontracting.

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##### Category IA:

- Pre-production meeting, as applicable, prior to the start of fabrication.
- Class survey during fabrication.
- Witness final functional, pressure and load tests, as applicable.
- Review fabrication record.

##### Category IB:

- Pre-production meeting (optional).
- Witness final functional, pressure and load tests, as applicable.
- Review fabrication record.

The extent of required survey by DNV is to be decided on the basis of manufacturer's QA/QC system, manufacturing survey arrangement (MSA) with DNV and type of fabrication methods

**105** Equipment of category II is normally accepted on the basis of a works certificate prepared by the manufacturer. The certificate shall contain the following data as a minimum:

- Equipment specification or data sheet.
- Limitations with respect to operation of equipment.
- Statement (affidavit) from the manufacturer to confirm that the equipment has been constructed, manufactured and tested according to the recognised methods, codes and standards.

##### Guidance note:

Independent test certificate or report for the equipment or approval certificate for manufacturing system may also be accepted.

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### B. Equipment Categorisation

#### B 100 General

**101** Categorisation of various equipment that is normally installed in production systems is given in 200 and 300. Equipment considered to be important for safety, which is not listed, shall be categorised after special consideration.

#### B 200 Pressure containing equipment and storage vessels

**201** Equipment categorisation for pressure containing equipment and storage vessels shall be according to Table B1.

Table B1 Categories for pressure containing equipment and storage vessels			
Property	Conditions	Category	
		I <sup>1)</sup>	II
Pressure	$1 < P \leq \frac{20000}{D_i + 1000}$		X
	$P > \frac{20000}{D_i + 1000}$	X	
	Vacuum or external pressure	X	
Medium	Steam	X	
	Toxic fluid	X	
	Thermal oil	X	
	Liquids with flash point below 100 °C	X	
	Flammable fluids with T > 150 °C	X	
	Other fluids with T > 220 °C	X	
	Compressed air/gas PV ≥ 1.5	X	
Material	$\sigma_y$ 345 MPa (50000 psi) or $\sigma_t$ 515 MPa (75000 psi)	X	
	Where impact testing is required. See Ch.2 Sec.9 C203.	X	
1) Normally category IA, however, limited class survey may be agreed upon with DNV based on manufacturer's QA/QC system, manufacturing survey arrangement (MSA) and fabrication methods.			

- P** = internal design pressure in bar  
**D<sub>i</sub>** = inside diameter in mm  
**V** = volume in m<sup>3</sup>  
**T** = design temperature  
**σ<sub>y</sub>** = specified yield strength  
**σ<sub>t</sub>** = specified ultimate tensile strength

**202** Categorisation of piping components shall be according to Table B2.

<b>Table B2 Categories for piping spools and components</b>				
Component	Application or rating or description	Category		
		IA	IB	II
Piping spools, skids, manifolds <sup>2)</sup>	Including supports and attachments	X		
Flanges and couplings <sup>1)</sup>	Standard type			X
	Non-standard type for high pressure, flammable or toxic fluids		X	
Valves	Standard valves to recognised standard			X
	Non-standard valves		X	
ESD and blow down valves	Including actuator and controls. Note 2		X	
Safety valves and rupture discs	2), 3)		X	
Christmas tree valves, blocks, connections etc.	Surface trees only, unless subsea trees are covered by extended scope	X		
Non-standard components	Including pressure retaining instruments and special piping parts. <sup>4)</sup>		X	
Expansion joints, bellows	For flammable or toxic fluids		X	
Flexible hoses	For flammable or toxic fluids	X		
Swivels and swivel stacks	For flammable or toxic fluids	X		
General instruments	Standard, well proven instruments, thermowells, pressure gauges, switches, control valves etc.			X
Flare and vent	Booms, stack or ground flare, including structures	X		
	Burners and flare tip			X
Hydraulic and pneumatic control and shutdown panels	5)	X		
<p>1) The extent of witnessing tests for category IA piping components may be agreed with DNV for spools etc. containing non-flammable, non-toxic fluids at low temperature (below 220 °C) and at low pressures (below 10 bar).</p> <p>2) A reduced categorisation may be agreed with DNV for spools etc. containing non-flammable, non-toxic fluids at low temperature (below 220 °C) and at low pressures (below 10 bar).</p> <p>3) Design review of valve and bursting disc is not required. The extent of witnessing of leak-, calibration-, capacity- and qualification- testing to be agreed with DNV based on manufacturer's QA/QC system. DNV shall normally witness batch qualification tests of bursting discs.</p> <p>4) Categorisation and approval procedure to be agreed with DNV on a case by case basis, considering selection of materials, service and complexity of design and fabrication method.</p> <p>5) The approval procedure to be agreed with DNV on a case by case basis, depending on function and criticality. See also relevant standards covering instrumentation and automation.</p>				

**203** Categorisation for mechanical equipment is to be according to Table B3.

<b>Table B3 Categorisation of mechanical equipment</b>				
Component	Application or rating	Category		
		IA	IB	II
Equipment train or skid	Compressor skid, export pump skid, power generation skid etc. <sup>1)</sup>	X		
Pumps	Non-standard design and construction	X		
	High capacity or high pressure, e.g. export, load out, booster, injection pumps etc.	X		
	Fire water pumps		X	
	Other general service and utility pumps			X
Gas compressors	All	X		
Air compressors	Non-standard design and construction	X		
	Other air compressors			X
Gas turbines	All	X		
Combustion engines	Non-standard design and construction	X		
	Capacity > 500 kW		X	
	Capacity < 500 kW			X
	For installation in hazardous area		X	
Electrical motors	Capacity > 100 kW		X	
	Capacity < 100 kW			X
Gears, shafts and couplings	2)		X	X
Switchgear assemblies and starters			X	
Monitoring and control systems			X	
Conductor or riser tensioning systems	For risers and conductors		X	
Riser quick disconnect system			X	
Lifting appliances	Permanent installations with in skids with SWL > 1000 kg. <sup>3)</sup>		X	
<p>1) The individual components within the equipment train are to be certified in accordance with requirements in Tables B1, B2 and B3. Other auxiliary systems are to be certified as required elsewhere in the rules, e.g. HVAC, and fire protection.</p> <p>2) Category for gears, shafts and couplings is to be either IB or II depending on the category of the prime mover.</p> <p>3) Certification will not cover lifting lugs and lifting points on the equipment itself.</p>				

**204** Categorisation for electrical equipment is to be according to Table B4.

<b>Table B4 Categorisation of electrical equipment</b>			
Component	Category		
	IA	IB	II
Motors with rating above 100 kVA		X	
Uninterruptable power supplies, including battery chargers, with rating above 100 kVA		X	
Explosion protected equipment if not carrying a certificate from a recognised test institution		X	
All other electrical equipment			X
Main control panels		X	
Instrumentation components in general			X

## B 300 Miscellaneous items

**301** The categorisation given in Table B5 normally apply for miscellaneous items relating to production plants.

<b>Table B5 Categorisation of miscellaneous items</b>			
<i>Component</i>	<i>Category</i>		
	IA	IB	II
Flare booms or towers	X		
Burner		X	
Flare		X	
Cold vents		X	
Tensioning system	X		

## SECTION 4

### SURVEY DURING CONSTRUCTION

#### A. General

##### A 100 General

**101** This section describes surveys during construction of an offshore production plant.

#### B. Quality Assurance or Quality Control

##### B 100 General

**101** The suppliers shall operate a quality management system applicable to the scope of their work. The system shall be documented and contain descriptions and procedures for quality critical aspects.

**102** Suppliers that do not meet the requirement in 101 will be subject to special consideration in order to verify that products satisfy the relevant requirements.

**103** The suppliers shall maintain a traceable record of non-conformities and corrective actions and make this available to the DNV surveyor on request.

##### Guidance note:

Suppliers are encouraged to obtain ISO 9000 quality system certification through DNV Accredited quality system certification services.

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#### C. Module Fabrication

##### C 100 General

**101** Where equipment is assembled as skid mounted units or modules, the surveyor shall inspect the fit-up, piping and electrical connections, and witness pressure and function test of the completed assembly in accordance with the approved documentation and test procedures.

#### D. Module Installation

##### D 100 General

**101** At the installation site, the surveyor shall witness the hook-up of flow lines to the production system, and the inter-

connection of piping and electrical systems between individual units and modules.

#### E. Specific Requirements in Relation to the Requirements of Ch.2 of this Standard

##### E 100 Welder qualifications

**101** Approval of welders shall be in accordance with DNV-OS-C401 or the applied design code.

**102** Welders already approved to another corresponding code than the design code, may be accepted if the approval is properly documented.

##### E 200 Welding

**201** Welding procedure specification (WPS) shall be approved by DNV.

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

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

**204** Welding repairs shall be performed according to a repair procedure approved by DNV.

**205** Local post weld heat treatment (PWHT) may be performed on simple joints when following an approved procedure. The procedure shall be approved by DNV.

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

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

**208** Magnetic particle inspection is the preferred method for detection of surface defects, however the liquid penetrant method may be used as an alternative, subject to DNV's acceptance in each case.

**209** Piping systems shall be cleaned (e.g. by flushing, retro-jetting, chemical cleaning etc.) to remove debris or foreign bodies prior to start-up of sensitive equipment like pumps, compressors, isolation valves etc. The procedure and acceptance criteria shall be agreed with the surveyor.

## SECTION 5 SURVEYS AT COMMISSIONING AND START-UP

### A. General

#### A 100 General

**101** Commissioning and start-up shall be in accordance with the submitted procedures reviewed and approved by DNV in advance of the commissioning. Commissioning and start-up testing shall be witnessed by a surveyor and is considered complete when all systems, equipment and instrumentation are operating satisfactorily.

### B. System and Equipment Checks

#### B 100 General

**101** During commissioning, all items of pipework and equipment shall be checked for compliance with approved documentation and commissioning procedures. Pressure vessels and connecting piping shall be pressure and leak tested. Electrical systems shall be checked for proper grounding and resistivity.

### C. Functional Testing

#### C 100 General

**101** During commissioning, the following systems shall be functionally tested, as practicable in accordance with approved procedures.

#### 102 Piping and equipment

- pressure and leak test
- purging.

#### 103 Utility systems

- power generation (main and emergency)
- process support systems
- instrument air
- cooling water.

#### 104 Fire-fighting and life saving systems

- fire pumps
- fixed systems
- manual equipment
- life saving equipment.

#### 105 Detection and alarm systems

- fire detection
- gas detection
- fire and gas panel
- PSD and ESD systems.

#### 106 Process systems

- flare
- instrumentation and control
- safety valves
- process components.

### D. Start-up

#### D 100 General

**101** A step-by-step procedure shall be followed for the displacement of air or other fluid from the process system prior to start-up. The surveyor shall be permitted access to suitable vantage points to verify that the start-up procedures are satisfactorily accomplished. The surveyor shall observe the plant operating at the initial production capacity. As applicable, the surveyor shall also observe the plant operating at various capacities under various conditions.

### E. Specific Requirements

#### E 100 General

**101** Testing of protection systems for process and utility systems and for critical equipment shall be in accordance with written test programmes that shall be accepted by DNV.

