OFFSHORE STANDARD
DNV-OS-E201

# OIL AND GAS PROCESSING SYSTEMS

OCTOBER 2010

DET NORSKE VERITAS

# FOREWORD

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DNV service documents consist of amongst other the following types of documents:

— *Service Specifications.* Procedual requirements.
— *Standards.* Technical requirements.
— *Recommended Practices.* Guidance.

The Standards and Recommended Practices 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
H) Marine Operations
J) Cleaner Energy
O) Subsea Systems

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# CHANGES

- **General**

This document supersedes DNV-OS-E201, October 2008.

## Main changes in October 2010:

— Offloading systems:

  — Requirements for offloading systems updated and expanded. Moved to a new separate Ch.2 Sec.12, stipulating requirements to design of arrangement, safety & control systems, hoses and hawsers of offloading systems.
  — Introducing a new voluntary class notation "**OFFLOADING**", granted to units complying with Ch.2 Sec.12 of the revised DNV-OS-E201.
  — Requirements for equipment certification - relevant for the **OFFLOADING** notation introduced in Ch.3.

— Ch.2 Sec.9 Materials and Corrosion Protection completely re-written for improved alignment with recognised industry codes and practice.
— General updating of references and editorial improvements based on experience feed-back from users.

# CONTENTS

**CH. 1 INTRODUCTION ..... 8**

A. General ..... 9
A 100 Introduction ..... 9
A 200 Objectives ..... 9
A 300 Organisation of this standard ..... 9
A 400 Scope and application ..... 9
A 500 Assumptions ..... 10

B. Normative References ..... 10
B 100 General ..... 10
B 200 DNV Offshore Standards, etc. ..... 10
B 300 Other references ..... 11

C. Definitions ..... 13
C 100 Verbal forms ..... 13
C 200 Definitions ..... 13
C 300 Abbreviations ..... 15

D. Documentation ..... 16
D 100 General ..... 16

**CH. 2 TECHNICAL PROVISIONS ..... 17**

A. General ..... 18
A 100 Overall safety principles ..... 18

B. Design Loads ..... 18
B 100 General principles ..... 18
B 200 Environmental conditions ..... 18
B 300 Design pressure and temperature ..... 19

C. Plant Arrangement and Control ..... 19
C 100 Operational considerations ..... 19
C 200 Monitoring, control and shutdown ..... 20
C 300 Shutdown devices and failure modes ..... 21
C 400 General requirements for valves ..... 21
C 500 Wellhead control system ..... 21
C 600 Subsea control system ..... 22

D. General ..... 23
D 100 General requirements ..... 23
D 200 Interconnection between hazardous and non-hazardous systems ..... 23

E. Wellhead and Separation System ..... 24
E 100 General ..... 24

F. Separator System ..... 24
F 100 General ..... 24

G. Gas Treatment and Compression System ..... 24
G 100 General ..... 24

H. Water Injection, Gas Injection and Gas Lift System ..... 25
H 100 General ..... 25

I. Heating and Cooling Systems ..... 25
I 100 General ..... 25

J. Chemical Injection Systems ..... 25
J 100 General ..... 25

K. Drainage Systems ..... 25
K 100 Open drainage system ..... 25
K 200 Additional requirements for closed drainage systems ..... 26

L. General ..... 27
L 100 General requirements ..... 27

M. Pressure Relief System ..... 27
M 100 General ..... 27

N. Depressurising System ..... 28
N 100 General ..... 28

O. Disposal System ..... 29
O 100 General ..... 29

P. General ..... 31
P 100 General ..... 31
P 200 Recognised codes ..... 31
P 300 Riser disconnection systems (for floating installations) ..... 31
P 400 Monitoring and control ..... 31

Q. Pig Launchers and Receivers ..... 31
Q 100 General ..... 31

R. Crude Export Pump Systems ..... 32
R 100 General ..... 32

S. Electrical Systems ..... 33
S 100 Application ..... 33

T. Instrumentation and Control Systems ..... 33
T 100 Application ..... 33
T 200 Scope ..... 33

U. System Requirements ..... 33
U 100 Clarification and amendments to system requirements in DNV-OS-D202 ..... 33

V. General ..... 35
V 100 Application ..... 35
V 200 Recognised codes and standards ..... 35

W. Design Requirements ..... 35
W 100 General ..... 35
W 200 Wall thickness ..... 36
W 300 Expansion joints and flexible hoses ..... 36
W 400 Valves and special items ..... 36
W 500 Piping connections ..... 36
W 600 Supporting elements ..... 37

X. General ..... 38
X 100 Application ..... 38

Y. Recognised Codes and Standards ..... 38
Y 100 Unfired pressure vessels ..... 38
Y 200 Boilers ..... 38
Y 300 Atmospheric vessels ..... 39
Y 400 Pumps ..... 39
Y 500 Compressors ..... 39
Y 600 Combustion engines ..... 39
Y 700 Gas turbines ..... 40
Y 800 Shafting ..... 40
Y 900 Gears ..... 40
Y 1000 Couplings ..... 40
Y 1100 Lubrication and sealing ..... 40
Y 1200 Wellhead equipment ..... 41
Y 1300 Lifting appliances ..... 41
Y 1400 Swivels and swivel stacks ..... 41
Y 1500 Risers ..... 41

Z. General ..... 42
Z 100 Application ..... 42
Z 200 Recognised codes and standards ..... 42

AA. Design Requirements ..... 42
AA100 General ..... 42

AB. Manufacture and Testing ..... 43
AB100 General ..... 43

AC. General ..... 44
AC100 Objective ..... 44

AD. Principles ..... 44
AD100 General ..... 44

AE.Specific Requirements ..... 44
AE100 Materials for load-carrying parts ..... 44
AE200 Bolts and nuts ..... 44

AF.Specific Requirements for Pressure Retaining Equipment ..... 45
AF100 Materials for pressure vessels, piping and equipment - General requirements ..... 45
AF200 Rolled steel, welded and seamless pipes ..... 45
AF300 Steel forgings ..... 45
AF400 Steel castings ..... 45
AF500 Aluminium, copper and other non-ferrous alloys ..... 45
AF600 Requirements to duplex stainless steel ..... 45
AF700 Bolts and nuts ..... 46
AF800 Sealing materials and polymers ..... 46

AG.Material Certificates ..... 46
AG100 General ..... 46
AG200 Type of document ..... 46

AH.Corrosion Protection ..... 47
AH100 General ..... 47

AI.Erosion ..... 48
AI 100 General ..... 48

AJ.General ..... 49
AJ 100 Application ..... 49
AJ 200 Quality assurance and quality control ..... 49
AJ 300 Marking ..... 49

AK.Manufacture ..... 49
AK100 Welder's qualification ..... 49
AK200 Welding ..... 49
AK300 Heat treatment ..... 49
AK400 Pipe bending ..... 50

AL.Non-destructive Testing (NDT) ..... 50
AL100 General ..... 50
AL200 Structures ..... 50

AM.Testing ..... 51
AM100 Testing of weld samples ..... 51
AM200 Pressure testing and cleaning ..... 51
AM300 Load testing ..... 51
AM400 Functional testing ..... 51

AN.General ..... 52
AN100 General ..... 52

AO.Scope and Application ..... 52
AO100 Scope ..... 52
AO200 Codes and standards ..... 52

AP.Technical Provisions ..... 53
AP100 General ..... 53
AP200 Initial gas treatment ..... 53
AP300 Liquefaction plant ..... 53
AP400 Regasification plant ..... 54
AP500 LNG transfer ..... 54
AP600 Pressure relief and depressurisation ..... 54
AP700 Piping systems ..... 55
AP800 Auxiliary systems ..... 55

AQ.General ..... 56
AQ100 General ..... 56

**CH. 3 CERTIFICATION AND CLASSIFICATION ..... 59**

A. General ..... 60
A 100 Introduction ..... 60
A 200 Class designation ..... 60
A 300 Assumptions ..... 60

B. General ..... 61
B 100 Application ..... 61

C. Specific Requirements for Certification or Classification ..... 61
C 100 General ..... 61
C 200 Design principles ..... 61
C 300 Electrical, instrumentation and control systems ..... 61
C 400 Piping ..... 61
C 500 Materials and corrosion protection ..... 61
C 600 Manufacture, workmanship and testing ..... 62

D. Documentation Requirements ..... 62
D 100 General ..... 62

E. General ..... 63
E 100 General ..... 63
E 200 Class designation ..... 64

F. Equipment Categorisation ..... 64
F 100 General ..... 64
F 200 Pressure containing equipment and storage vessels ..... 64
F 300 Miscellaneous items ..... 67

G. General ..... 68
G 100 General ..... 68

H. Quality Assurance or Quality Control ..... 68
H 100 General ..... 68

I. Module Fabrication ..... 68
I 100 General ..... 68

J. Module Installation ..... 68
J 100 General ..... 68

K. Specific Requirements in Relation to the Requirements of Ch.2 of this Standard ..... 68
K 100 Welder qualifications ..... 68
K 200 Welding ..... 68

L. General ..... 70
L 100 General ..... 70

M. System and Equipment Checks ..... 70
M 100 General ..... 70

N. Functional Testing ..... 70
N 100 General ..... 70

O. Start-up ..... 71
O 100 General ..... 71

P. Specific Requirements ..... 71
P 100 General ..... 71

OFFSHORE STANDARD
DNV-OS-E201

OIL AND GAS PROCESSING SYSTEMS

CHAPTER 1

# INTRODUCTION

CONTENTS PAGE

Sec. 1 Introduction ..... 9

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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.

The standard also covers liquefaction of natural gas and regasification of liquefied natural gas and also associated gas processing.

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

Offshore installations include fixed and floating terminals for export or import of LNG.

**103** The requirements of Ch.2 relate primarily to oil and gas production activities. Ch.2 Sec.11 provides additional requirements to LNG terminals and should be read as a supplement to the other sections in Ch.2.

**104** 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 and LNG processing plant 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 and LNG processing plant 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 and LNG processing plant 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
— LNG Liquefaction system
— LNG regasification system
— LNG transfer 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
— Shutdown valve between liquefaction plant and LNG storage tanks
— Shutdown valve between LNG storage and regasification plant, and between regasification plant and export line.

### A 500 Assumptions

**501** The requirements apply to oil and gas processing 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-D201 | Electrical Installations |
| DNV-OS-D202 | Automation, Safety, and Telecommunication Systems |
| DNV-OS-D301 | Fire Protection |
| DNV-OS-F101 | Submarine Pipeline Systems |
| DNV-OS-F201 | Dynamic Risers |
| Classification Note 41.2 | Calculation of Gear Rating for Marine Transmission |
| | Rules for Certification of Flexible Risers and Pipes |
| | Rules for Classification of Ships |
| DNV Standard for Certification No. 2.22 | 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.

| **Table B2 Other references** | |
|---|---|
| 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 505 | Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, and Zone 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 |
| 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 |

| **Table B2 Other references (Continued)** | |
|---|---|
| Code | *Title* |
| 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 |
| ASTM A923 | Standard Test Methods for Detecting Detrimental Intermetallic Phase in Wrought Duplex Austenitic/Ferritic Stainless Steels |
| 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 5950 | Structural use of steelwork in building |
| PD 5500 | Specification for unfired fusion welded pressure vessels |
| DIN 4119 | Above-ground Cylindrical Flat-bottomed Tank Installations of Metallic Materials |
| DNV-RP-A201 | Plan Approval Documentation Types - Definitions |
| DNV-RP-D101 | Structural analysis of Piping systems |
| DNV-RP-O501 | Erosive Wear in Piping Systems |
| EEMUA publication 107 | Recommendations for the Protection of Diesel Engines for Use in Zone 2 Hazardous Areas |
| EN 13480 | Metallic Industrial Piping |
| EN 1473 | Installation and equipment for liquefied natural gas: Design of onshore installations |
| EN 1474 | Installation and equipment for liquefied natural gas: Design and testing of loading/unloading arms |
| EN 12952 | Water-tube boilers and auxiliary installations |
| EN 12953 | Shell Boilers |
| EN 13445 | Unfired pressure vessels |
| 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’ |
| IGC Code | The International Code for the Construction and Equipment of Ships carrying Liquefied Gases in Bulk |
| 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 |
| ISO 10418 | Petroleum and natural gas industries - Offshore production platforms - Analysis, design, installation and testing of basic surface safety systems |
| 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 13631 | Packaged reciprocating gas compressors |
| ISO 15156 | Materials for Use in H2S-containing Environments in Oil and Gas Production |
| 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 |
| NFPA 59A | Standard for the Production, Storage, and Handling of Liquefied Natural Gas |
| NS 3471 | Prosjektering av aluminiumskonstruksjoner - 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 |
| 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 visual and audible signal for warning of an abnormal condition, where the audible part calls the attention of personnel, and the visual part serves to identify the abnormal condition.

**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 station or Control room*: General term for any location space where essential control functions are performed during transit, normal operations or emergency conditions. Typical examples are central control room, radio room, process control room, bridge, emergency response room, etc. For the purpose of compliance with the SOLAS Convention and the MODU Code, the emergency generator room, UPS rooms and fire pump rooms are defined as control stations.

**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 ºC (100 ºF) and having a vapour pressure not exceeding 2.8 kg/cm$^2$ (40 psi absolute) at 37.8 ºC (100 ºF).

**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** *High Integrity Pressure Protection System (HIPPS)*: A highly reliable, self contained, instrumented safety system to protect against overpressure.

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

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

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

**231** *Installation*: An offshore platform which may be either bottom-founded (permanently affixed to the sea-floor) or floating.

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

**233** *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.

**234** *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.

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

**236** *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).

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

**238** *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.)

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

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

**241** *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.

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

**243** *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.

For LNG terminals this may also include processes in connection with liquefaction and regasification.

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

**245** *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).

**246** *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.

**247** *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.

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

**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, hydraulic power, 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. |
| EN | EuroNorm |
| 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 |
| LER | Local Equipment Room |
| LIR | Local Instrument Room |
| LNG | Liquefied Natural Gas |
| LRFD | Load and resistance factor design |
| MAWP | Maximum allowable working pressure |

| Table C1 Abbreviations (Continued) | |
|---|---|
| *Abbreviation* | *Meaning* |
| 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 |
| 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) Shutdown philosophy

g) 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.).

h) Sizing calculations for relief valves, bursting discs and restriction orifices.

i) Flare radiation calculations and plots.

j) Cold vent dispersion calculations and plots.

k) HAZOP study report.

l) 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.).

m) Line list.

n) Arrangement showing the location of main electrical components.

o) "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.

OFFSHORE STANDARD
DNV-OS-E201

OIL AND GAS PROCESSING SYSTEMS

CHAPTER 2

# TECHNICAL PROVISIONS

CONTENTS PAGE


Sec. 1 Design Principles ..... 18
Sec. 2 Production and Utility Systems ..... 23
Sec. 3 Relief and Depressurising Systems ..... 27
Sec. 4 Hydrocarbon Import/ Export ..... 31
Sec. 5 Electrical, Instrumentation and Control Systems ..... 33
Sec. 6 Piping ..... 35
Sec. 7 Equipment ..... 38
Sec. 8 Structures ..... 42
Sec. 9 Materials and Corrosion Protection ..... 44
Sec. 10 Manufacture, Workmanship and Testing ..... 49
Sec. 11 Supplementary Provisions for LNG Import and Export Terminals (and LNG Production Units) ..... 52
Sec. 12 Crude Offloading System (for Floating Installations) ..... 56



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# SECTION 1
# DESIGN PRINCIPLES

## A. General

### A 100 Overall safety principles

**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 browse 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** Unintentional closing of valves due to flow or vibration induced loads shall be prevented.

**Guidance note:**

This requirement may be met by a physical lock.

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**406** 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 (¾ 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 re-boiler 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 D102 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 bunded 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 bunded 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$^2$ (2000 Btu/hr/ft$^2$) 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$^2$ (1500 Btu/hr/ft$^2$) in areas where emergency actions lasting several minutes may be required by personnel without shielding but with appropriate clothing
— 1.6 kW/m$^2$ (500 Btu/hr/ft$^2$) 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
# HYDROCARBON IMPORT/ EXPORT

## 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, and to crude oil export arrangements.

**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).

**106** Pig launchers and receivers are to be designed and manufactured according to a recognised pressure vessel code /ref Ch 2 Sec 7/.

## 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.

# 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.

**Guidance note:**

From a safety point of view loss of power to the process plant will not normally be considered as hazardous as long as the control and safety functions described in Subsection B function satisfactorily. Therefore availability and redundancy of power to the process plant will normally be a matter for the Operator to specify. Requirements related to these parameters in DNV-OS-D201 need not be complied with.

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**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 30 minutes.

**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* |
|---|---|
| ASME B31.3 | Process Piping |
| API RP 14E | Design and Installation of Offshore Production Platform Piping Systems |
| API RP 14C | Recommended Practice for Analysis, Design, Installation and Testing of Basic Surface Safety Systems for Offshore Production Platforms |
| EN13480 | Metallic Industrial Piping |
| DNV-RP-D101 | Structural Analysis of Piping Systems |

**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
— accidental loads
— 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 pressure strength tickness of piping and piping components shall be calculated according to ASME B31.3 Process Piping.

**203** Calculation for the reinforcement is needed when weldolets of unrecognised type and shape are used in a branch connection. Code requirements to such calculations are given in ASME B31.3, section 304.3. Requirements to bracing of weldo-flanges subjected to vibrations are given in B104 above.

### 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** The flexible hose has to maintain its integrity and functional properties for the same period as required for the total piping system and components. Ref. also DNV-OS-D101 Ch.2 Sec.2 B500.

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

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

**505** 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** High pressure piping: piping attachements such as pipe supports, trunnions, bracings and lifting lugs shall not be welded directly to high pressure piping as defined in ASME B31.3, Chapter IX, K300. Gland type (stuffing box) penetrations shall be applied for pipe penetrations through decks or bulkheads.

**605** Ordinary piping: Piping attachements such as pipe supports, trunnions, bracings and lifting-lugs shall in general not be welded directly yo ordinary piping. Ordinary piping is herein defined as piping in accordance with the ASME B36.10 and ASME B36.19 standards and with pressure-temperature ratings as given in ASME B16.5 (150 lb - 2500 lb).

When doubling plates are not used, the additional stresses from local buckling and point loads from bening moments, shear-and radical thrust load from attachments at the contact points need to be document.

**Guidance note:**

The well know "M.W. Kellogg Methodology" for calculation of additional pipe stresses has over decades proved to give safe and conservative solutions to the problem with calculation of trunnion-type pipe supports. For more sophisticated analysis (in order to document that a doubling plate required according to the conservative Kellog Methodolgy can be avoided), the methodology given in ASME VIII, Div. 2, section 4 or 5 can be used to document the necessary structural integrity.

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**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 ± 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 and heat exchangers are listed in Table B1.

**Table B1 Recognised codes for unfired pressure vessels and heat exchangers**

| *Code* | *Title* |
|---|---|
| ASME | Boiler and Pressure Vessels Code, Section VIII, Pressure Vessels |
| PD 5500 | Specification for unfired fusion welded pressure vessels |
| Rules for Classification of Ships Pt.4 Ch.7 | Boilers, pressure vessels, thermal-oil installations and incinerators |
| TEMA | Standards for Heat Exchangers |
| EN 13445 | Unfired Pressure Vessels |

### B 200 Boilers

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

| Table B2 Recognised codes for boilers | |
|---|---|
| *Code* | *Title* |
| ASME | Boiler and Pressure Vessel Code, Section I, Power Boilers |
| ASME | Boiler and Pressure Vessel Code, Section IV, Rules for Construction of Heating Boilers |
| EN 12952 | Water-tube boilers and auxiliary installations |
| EN 12953 | Shell boilers |
| BSI PD 5500 | Specification for unfired fusion welded pressure vessels |
| Rules for Classification of Ships Pt.4 Ch.7 | Boilers, pressure vessels, thermal-oil installations and incinerators |

### B 300 Atmospheric vessels

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

| Table B3 Recognised codes for atmospheric vessels | |
|---|---|
| *Code* | *Title* |
| 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 Pumps

**401** Recognised codes for pumps are given in Table B4.

| Table B4 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.6 Sec.6 | Piping systems, Pumps |

### B 500 Compressors

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

| Table B5 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 |
| ISO 13631 | Packaged reciprocating gas compressors |
| Rules for Classification of Ships Pt.4 Ch.5 Sec.4 | Rotating Machinery, Driven Units |

### B 600 Combustion engines

**601** Recognised codes for combustion engines are given in Table B6.

| Table B6 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.3 Sec.1 | Rotating Machinery, Drivers |

## B 700 Gas turbines

**701** Recognised codes for gas turbines are given in Table B7.

| **Table B7 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.3 Sec.2 | Rotating Machinery, Drivers |

## B 800 Shafting

**801** Recognised codes for shafting are given in Table B8.

| **Table B8 Recognised codes for shafting** | |
|---|---|
| *Code* | *Title* |
| Rules for Classification of Ships Pt.4 Ch.4 Sec.1 | Rotating Machinery, Power transmission |

## B 900 Gears

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

| **Table B9 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.4 Sec.2 | Rotating Machinery, Power transmission |

## B 1000 Couplings

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

| **Table B10 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.4 Sec.3 through 5 | Rotating Machinery, Power transmission |

## B 1100 Lubrication and sealing

**1101** Recognised codes for lubrication and sealing are given in Table B11.

| **Table B11 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 1200 Wellhead equipment

**1201** Recognised codes for wellhead equipment are given in Table B12.

| Table B12 Recognised codes for wellhead equipment | |
|---|---|
| *Code* | *Title* |
| 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 Subsurface Safety Valve Systems |
| API RP 14H | Installation, Maintenance and Repair of Surface Safety Valves and Underwater Safety Valves Offshore |
| 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 1300 Lifting appliances

**1301** Recognised codes for lifting appliances are given in Table B13.

| Table B13 Recognised codes for lifting appliances | |
|---|---|
| *Code* | *Title* |
| API Spec 2C | Offshore Cranes |
| DNV Standard for Certification No. 2.22 | Lifting Appliances |

### B 1400 Swivels and swivel stacks

**1401** Recognised codes for swivels and swivel stacks are given in Table B14.

| Table B14 Recognised codes for swivels and swivel stacks | |
|---|---|
| *Code* | *Title* |
| API RP 2FPS | Recommended Practice for Planning, Designing, and Construction Floating Production Systems-First Edition |

### B 1500 Risers

**1501** Recognised codes for risers are given in Table B15.

| Table B15 Recognised codes for risers | |
|---|---|
| *Code* | *Title* |
| DNV OSS-302 | Recommended Practice for Planning, Designing, and Construction Floating Production Systems-First Edition |

# 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 (LRFD 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* 1) |
|---|---|
| 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 2) |
| Support for flare structure | Special 2), 3) |
| Supports for conductors and risers | Special 3) |
| Pipe racks and pipe supports | Secondary |

1) The various categories are defined in DNV-OS-C101.
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.
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.

**102** Permanent lifting points, runway beams etc. attached to structures shall be designed in accordance with the DNV Standard for Certification No. 2.22 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 $H_2S$ contaminated products (sour service), see ANSI/ NACE MR0175 and ISO 15156.

## C. Specific Requirements

### C 100 Materials for load-carrying parts

**101** 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:

— $C \leq 0.22\%$

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

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

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

**102** 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.

**103** 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.

**104** 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 $HV_5$ in the final heat treated condition. For other steel materials, see NACE MR0175/ISO 15156, concerning allowable hardness.

**105** 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%.

**106** The material shall have a supply condition, chemical composition, mechanical properties, weldability and soundness as described in DNV-OS-B101. including extent of testing. Other standards giving comparable parameters may be used upon special agreement.

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

### C 200 Bolts and nuts

**201** Bolts and nuts essential for structural and operational safety shall conform to a recognised standard, e.g. ISO 898 for carbon steel and low alloy bolting and ISO 3506 for corrosion resistant bolting.

**202** 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.

**203** For topside applications, carbon steel and low alloy fasteners shall be hot dipped galvanised or have similar corrosion protection.

The hardness of bolts and nuts in low alloy and carbon steels subjected to cathodic protection shall not exceed 350 HV in order to restrict damage by HISC.

## D. Specific Requirements for Pressure Retaining Equipment

### D 100 Materials for pressure vessels, piping and equipment - General requirements

**101** Materials for pressure equipment, hydraulic cylinders and piping shall be in accordance with the requirements given by the agreed design code.

**102** Requirement to Charpy V-notch testing is specified by the design code for the system which the component is a part of. The impact test energy requirement shall be according to the material standard or to the piping and pressure equipment design code, whichever is stricter. Additional requirements for certain steels and product forms are given below.

**Guidance note:**

For components that show significant reduction in impact properties after welding, proper account of this behaviour should be taken into consideration when deciding the requirements for the base material. To be able to meet the code requirement for the finished weld for such materials, it is recommended to have a certain reserve in impact properties.

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**103** 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.

### D 200 Rolled steel, welded and seamless pipes

**201** Rolled plates for pressure equipments shall be made to recognised standard such as ASTM A240/A516, EN 10028 or equivalent.

**202** Welded pipes shall be made to recognised standard such as DNV-OS-F101, API 5L/ISO 3183, ASTM A671/A928, EN 10217 or equivalent.

**203** Seamless pipes shall be made to a recognised standard such as DNV-OS-F101, API 5L/ISO 3183, ASTM A333/A790, EN 10216 or equivalent.

### D 300 Steel forgings

**301** Steel forgings shall be made to a recognised standard such as ASTM A105/A182/A350/A694, EN 10222 or equivalent.

**302** Steel bars shall be made to a recognised standard such as ASTM A276, EN 10272/10273 or equivalent.

**303** Wrought fittings shall be made to recognised standard such as ASTM A234/A420/A860/A403/A815 or equivalent.

**304** Hot Isostatic Pressing (HIP) is an acceptable manufacturing route. HIP material test regime and acceptance criteria shall be subject to agreement.

### D 400 Steel castings

**401** Steel castings shall be made to a recognised standard such as ASTM A216/A351/A352/A995, EN 10213 or equivalent.

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

### D 500 Aluminium, copper and other non-ferrous alloys

**501** 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.

### D 600 Requirements to duplex stainless steel

**601** Duplex stainless steels have to be quenched in a fairly narrow cooling rate interval. A too slow cooling rate will result give inter-metallic phases precipitate. A too fast cooling rate will give a too high ferrite content. Both are detrimental to the material properties. However, in thick sections it is difficult to avoid poorer material properties toward the middle, if the surface material shall meet the requirements. Hence it shall be documented,

through the design process and relevant mechanical testing, that poorer material properties in the middle of the sections are not detrimental to the integrity of the component.

**602** Duplex stainless steels and austenitic stainless steel of type 6Mo shall be corrosion tested according to ASTM G48 method A. Test temperature 25ºC for 22Cr and 50ºC for 25Cr and 6Mo, exposure time 24 hr. Weight loss less than 4.0 g/m$^2$.

**603** Hardness shall be maximum:

— For 22 Cr Duplex: 290 HV10 or 28 HRC
— For 25 Cr Duplex: 330 HV10 or 32 HRC

**604** The ferrite content of duplex stainless steels shall be determined according to ASTM E 562 or equivalent and shall be within 35-55 %. The microstructure, as examined at 400 X magnification on a suitably etched specimen, shall be free from inter-metallic phases and precipitates.

**605** Duplex stainless steels shall be Charpy impact tested at the minimum design temperature, or lower. Acceptance criteria shall be 45 J average of 3 specimens in a set, 30 J single individual value. For the minimum design temperature we refer to ASTM A923.

### D 700 Bolts and nuts

**701** Bolts and nuts for all pressure equipment shall conform to a recognised standard, e.g. ASTM A193 for bolts/ASTM A194 for nuts or EN10269 for fasteners to European standard.

**702** For equipment submerged in seawater, the specified tensile properties are not to exceed what is specified for ASTM A193 grade B7 / EN 10269 42CrMo4.

To restrict damage by HISC for low alloy and carbon steels, the hardness for any bolts and nuts to receive cathodic protection shall not exceed 350 HV.

**Guidance note:**

*For bolted joints to be part of equipment designed for sulphide stress cracking service, lower tensile properties than for B7 may be necessary in order to comply with NACE MR0175 / ISO 15156. External bolts not directly exposed to the medium need not to meet this requirement.*

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### D 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.

## E. Material Certificates

### E 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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### E 200 Type of document

**201** Material certificate types shall be as given in Table E1.

**202** Material certificate type 3.2 is required for material for pressure retaining equipment in category I unless an acceptable Works Certificate can be produced.

**203** Material certificate type 3.2 from a works approved by DNV is required for structures in category special and primary.

**204** Work certificates type 3.1 is required for material for structures in other categories, for piping components and pressure retaining equipment in category II.

**Guidance note:**

The manufacturer must have a quality assurance system certified by a competent body

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**205** Test report is acceptable for other components.

| **Table E1 Material certification** | |
|---|---|
| *Certification process* | *EN 10204* |
| *Test report*<br>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 |
| *Inspection certificate (Works Certificate)*<br>Test results of all specified tests from samples taken from the products supplied. Inspection and tests witnessed and signed by QA department | 3.1 |
| *Inspection certificate (Test Certificate)*<br>As work certificate, inspection and tests witnessed and signed by QA department and an independent third party body | 3.2 |

## F. Corrosion Protection

### F 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** | |
|---|---|
| *Service* [1)] | *c (mm)* |
| 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 | |

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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.

## G. Erosion

### G 100 General

**101** Precautions shall be taken to monitor and avoid erosion in process piping and equipment. For further information, we refer to DNV-RP-O501.

# 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* 4) | *Visual inspection, see 106* | *Radiography, see 104* | *Magnetic particle, see 105* |
|---|---|---|---|---|
| up to 150# rating and 185 ℃ 1) | L | 100% | 10% | 10% |
| | C | 100% | 5% | 5% |
| | B | 100% | - | 10% |
| 300# rating 2) | L | 100% | 20% | 20% |
| | C | 100% | 10% | 10% |
| | B | 100% | - | 100% |
| over 300# rating 3) | 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 $H_2S$ 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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# SECTION 11
# SUPPLEMENTARY PROVISIONS FOR LNG IMPORT AND EXPORT TERMINALS (AND LNG PRODUCTION UNITS)

## A. General

### A 100 General

**101** The following requirements apply specifically to LNG terminals. They will be applicable to both floating and fixed installations.

**102** These requirements should be considered as supplementary to the requirements given in the main body of this document.

**103** Design should consider the philosophy with respect to in-service access for inspection, repair, maintenance and replacement. It will be up to the designer to link the level of desired availability to the specification of such systems.

## B. Scope and Application

### B 100 Scope

**101** This standard covers gas liquefaction plant and LNG regasification plant. The LNG transfer system between a gas carrier and the terminal is also covered. The term *Transfer* includes both loading and unloading.

**102** LNG storage is covered in DNV-OS-C503 Concrete LNG Terminal Structure and Containment Systems for concrete installations and DNV-OS-C107 Steel LNG Terminal Structure and Containment Systems (under development - see Note:) for steel installations.

**Note:**
For information concerning the referenced document "DNV-OS-C107 "Steel LNG Terminal Structure and Containment Systems" (currently under development), contact TNCNO725, DNV, Høvik, Norway.

### B 200 Codes and standards

**201** The following codes and standards may be used as reference in design of the liquefaction and regasification plant:

**Table B1 Codes and Standards - listing for the liquefaction and regasification plant**

| *Code* | *Title* |
|---|---|
| *Overall Safety* | |
| NFPA 59A | Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG) |
| EN 1473 | Installation and Equipment for Liquefied natural Gas : Design of onshore installations |
| *System Safety* | |
| API RP 14C | Analysis, Design, Installation and Testing of Basic Surface Safety Systems for Offshore Production Platforms |
| ISO 10418 | Petroleum and natural gas industries – Offshore production platforms – Analysis, design, installation and testing of basic surface safety systems |
| *Process Plant Equipment* | |
| TEMA | Tubular Exchanger Manufacturers Association |
| NFPA 37 | Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines |
| ASME VIII | Boiler and Pressure Vessel Code |
| API RP 520 | Sizing, Selection and Installation of Pressure Relieving Devices in Refineries |
| API RP 521 | Guide for Pressure Relieving and Depressurising Systems |
| API Std 610 | Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services |
| API Std 6D | Specification for Pipeline Valves |
| API Std 617 | Axial and Centrifugal Compressors and Expander 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 |
| PD 5500 | Specification for unfired fusion welded pressure vessels |
| EN 13445 | Unfired pressure vessels |

| Table B1 Codes and Standards - listing for the liquefaction and regasification plant (Continued) | |
|---|---|
| *Code* | *Title* |
| *Process Piping* | |
| ASME B31.3 | Process Piping |
| API 14E | Design and Installation of offshore production platform piping systems |
| *Fuel Gas System* | |
| IGC Code | International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk |
| DNV OS D101 | Marine and Machinery Systems and Equipment |

**202** The following codes and standards may be used as reference for the LNG transfer system.

| Table B2 Codes and Standards - listing for the LNG transfer system | |
|---|---|
| *Code* | *Title* |
| NFPA 59A (Chap 8) | Standard for Production, Storage and handling of Liquefied Natural Gas |
| EN 1474 | Installation and Equipment for Liquefied natural Gas: Design and Testing of loading/unloading arms |
| OCIMF | Design and Construction Specification for Marine Loading Arms, 3rd ed 1999 |
| SIGTTO/ICS/ OCIMF | Ship to Ship Transfer Guide (Liquefied Gas), 2nd ed. 1995 |
| ICS | Tanker Safety Guide (Liquefied Gas), 2nd ed. 1995 |
| SIGTTO | Liquefied Gas Handling Principles on Ships and in Terminals, 2nd ed. 1996 |
| OCIMF | Mooring Equipment Guidelines, 2nd ed. 1997 |
| OCIMF: Oil Companies International Marine Forum<br>SIGTTO: Society of International Gas Tanker and Terminal Operators<br>ICS: International Chamber of Shipping | |

**203** In using existing codes and standards consideration should be given to their origin, applicability and limitations. The design must consider the intended specific application.

## C. Technical Provisions

### C 100 General

**101** Installations may engage in gas treatment, gas liquefaction, LNG storage, LNG transfer, LNG regasification, gas export, condensate storage, condensate export depending on whether the terminal is an import or an export terminal. The design shall take into account the hazards associated both with the individual activities and also those associated with combined operations. This shall be addressed in a safety assessment, ref DNV-OS-A101.

### C 200 Initial gas treatment

**201** Gas treatment prior to liquefaction, e.g. for removal of acid gases, dehydration and mercury removal, shall be designed and constructed in accordance with the requirements of the main body of this standard for similar plant on oil and gas production facilities

**202** Any constituents of the feed gas flowing to a liquefaction plant, which may become solid at the low temperatures, shall be removed to the extent that the remaining amounts of such constituents will either stay in solution or be of such concentrations as to create no significant problems, fouling or plugging.

### C 300 Liquefaction plant

**301** The inventory in liquefaction plant should be minimised as far as possible

**302** Leakage from cryogenic sections of the process should be contained and drained. Areas likely to be affected by such leakage should be designed to withstand low temperature or be protected against it by shielding or water spray.

**303** On floating installations, all equipment should be designed to operate safely within specified installation motions. Special attention should be paid to design, support and location of fractionation towers and other tall structures

**304** The design should ensure that contamination of the cooling medium by the product will not occur.

### C 400 Regasification plant

**401** Selection of vaporiser should consider environmental impact in terms of air emissions, use of biocides, or changes in seawater temperature.

**402** For floating installations selection and location of vaporiser should consider ability to function during motion of the installation.

### C 500 LNG transfer

**501** Operational limitations for the transfer operation should be set with respect to parameters such as :

— Sea conditions for safe approach, berthing and departure of the LNG carrier
— Operational envelope of the loading arms (relative motion, accelerations)
— Loads in the mooring lines and fenders between the terminal and the carrier

**502** Where existing technology is intended to be used, any differences in operation and loading from typical usage are to be addressed and the ability of the system to perform satisfactorily is to be documented.

**503** Where novel transfer solutions are intended to be used, the technology is to undergo some form of qualification. Reference is made to DNV-RP-A203 *"Qualification Procedures for New Technology"*.

**504** The transfer system shall be fitted with a Quick Connect Disconnect Coupling (QCDC) to be used in normal operation of the transfer system.

**505** The QCDC system is to be fitted with an interlock to prevent inadvertent disconnection while transfer is underway or the lines are under pressure.

**506** The transfer system is to be fitted with an Emergency Release System (ERS), which will permit rapid disconnection in the event of an emergency

**507** The control of the ERS is to be arranged to prevent inadvertent operation of the system. Testing of the ERS function should be possible without releasing the coupling.

**508** The Emergency Release system is to be fitted with means to minimise any leakage in the event of operation of the system. This may typically involve installation of valves on each side of the separated connection

**509** The transfer system is to be designed to accommodate any LNG remaining in the transfer system either following normal disconnection or emergency disconnection.

**510** Any structural elements which might be exposed to spillage of cryogenic fluid are to be either designed for such exposure or protected against exposure by shielding or by water spray.

**511** Effects of possible leakage of LNG on to water between the terminal and the carrier should be documented (i.e. rapid phase transition scenario).

**512** The transfer control system must be linked to the ESD system, communication system, and carrier berthing system (line tension and release systems) to permit a safe disconnect in the event of an emergency.

**513** Pumps used in LNG service should be designed for the most demanding LNG density which may be encountered.

**514** Pumps used for transfer of liquids at temperatures below –55°C, shall be provided with suitable means for pre-cooling to reduce the effect of thermal shock.

### C 600 Pressure relief and depressurisation

**601** Design of pressure relief shall consider capacity required in a an accident or maloperation scenario. The various scenarios shall be identified in a HAZOP:

**602** The relief and depressurisation system shall consider a fire case scenario. The fire scenario shall be determined by risk assessment.

**603** Where a flare is installed the design shall consider the effect of radiation on the installation and the possibility for safe escape and evacuation.

**604** Where a vent arrangement is selected, the extent and consequence of a gas cloud formation should be considered. A dispersion analysis considering dense gas and worse case release and environmental conditions should be carried out.

**605** The vent or flare arrangement shall generally be designed to accommodate the maximum possible release. A design which is based on a HIPPS system rather than relief of full flow will need to be justified in terms of reliability and overall safety considerations

**606** A vent / depressurisation arrangement shall be arranged for process segments which may be isolated as part of the shutdown arrangement.

**607** The gas disposal system shall be separated such that hydrate and ice formation is eliminated. Adequate separation shall be obtained for cold gas and liquids from wet gas.

### C 700 Piping systems

**701** Process piping should as far as possible be fully welded. For special requirements for LNG or LPG cargo piping systems see the Rules for Classification of Ships Pt.5 Ch.5 Sec.6

**702** Flanges shall be avoided as far as possible in all low temperature piping. Where flanges are unavoidable, due consideration shall be given to the effects of thermal contraction and expansion

**703** Piping stress analysis shall be carried out on LNG/NG-containing piping. For floating installations the analysis shall consider motion of the installation.

### C 800 Auxiliary systems

**801** The availability of auxiliary systems serving the process system and on which the process system may depend should also be considered in selection of design code and specification of such systems.

**802** The design should ensure that cross contamination of auxiliary systems with hydrocarbons will be adequately protected against.

# SECTION 12
# CRUDE OFFLOADING SYSTEM (FOR FLOATING INSTALLATIONS)

## A. General

### A 100 General

**101** The offloading system shall be designed such that a single failure, mal-operation, operation or emergency operation shall not result in:

— personnel injury
— significant release of hydrocarbons
— significant mechanical damage.

**102** The system details of the offloading system shall be declared in a protection philosophy document declaring the mooring line and hose release systems in respect of normal operation and emergency release. The philosophy shall include a system diagram, showing all instruments, safety devices, interlocks and the telemetry system installed.

The design limitations of the system shall be clearly stated and at least include flow rates, design pressurse, temperatures, minimum hose bending radius, breaking loads as well as operational weather limitations.

**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, 4th edition, 1991, is a recognised standard, which requires that the hose is electrically continuous and isolated at the receiving installation to avoid current loops. The hose shall be electrically connected to the delivery installation. See ICS/OCIMF Ship to Ship transfer Guide (Petroleum) 4th edition 2005, ch.3.6

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**104** The loading hose and hawser for units with the loading hose in the water, shall be arranged such that they cannot come in contact with the propellers on the unit or shuttle tanker during normal operations.

**105** The hawser shall, as a minimum, have a safety factor of 3 against failure.

**106** The design load for the mooring line emergency disconnect system and its foundation shall be the minimum breaking strength of the mooring line. The maximum stress in the disconnect system shall not exceed the yield stress or 80% of the minimum breaking stress, whichever is lower.

**Guidance note:**

It is assumed that hawsers are replaced according to predefined intervals according to specification from the maker.

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**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

**108** Hose reels shall be fitted with a reel locking mechanism and a fail safe closed isolation valve immediately upstream of the reel. The valve shall be fitted with end of travel position indication in the control station. The activation system of the valve shall be electrically connected into the loading control system, emergency disconnect system and the emergency shutdown system

**109** 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.

**110** Piping shall meet the requirements of section 6 of this standard, shall be self draining and of welded construction with the minimum number of flanged connections. Connections shall be incorporated to inert and clean the offloading system all the way to the receiving installation.

**111** Facilities shall be provided to drain the offloading system including the loading hose. The hose shall be purged after each offloading operation.

**112** Bunds shall be provided for collection of possible leakage from loading hose end-connections during storage. The height of bunds must take operational movements of the unit into account.

**113** 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.

**114** 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.

**115** In addition to 114, a local control station with direct view of the operation shall be provided in the vicinity of the offloading hose. This control station is to be used when connecting the hose to the shuttle tanker. After connection, the remote monitoring station shall be used.

**116** CCTV cameras shall be of adequate quality with necessary manipulation functions available. Wiper and cleaning functions shall also be implemented.

**117** The remote control station mentioned in 115 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, overpressure ventilation and enclosed escape routes may be alternative solutions.

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

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

**119** 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).

**120** The following functions shall be possible from the control station(s) of the unit (FPSO/FSO):

— control and monitoring of operations
— shutdown of offloading operations
— remote/ local emergency release of hawser connections located on the unit
— remote/local emergency release (from the FPSO/FSO) of the hose connection located on the unit.

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

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

**122** For the shutdown as listed in par. 120 and 121, the closing time shall not exceed 20 sec.

**123** The automatic release system shall be fail safe and normally de-energised, with energy for actuated devices supplied from a local source. The manual release system shall be independent of the automatic system.

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

**125** The automatic release control shall be divided into two modes.

1) The first mode shall perform the following functions:

— tripping the main crude oil transfer pumps
— closing the connector and loading hose end coupler valves.

**Guidance note:**

Minimum valve closing time should normally not be less than 25 s.

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2) The second mode shall perform the following functions:

— tripping the main crude oil transfer pumps
— closing of the connector and loading hose end coupler valves
— opening of the coupler.

All functions shall be performed in sequence.

**126** In addition to the above automatic disconnection systems, a manually-operated backup emergency disconnection system shall be provided. By this system, individual operation of the chain stopper and coupling bypass locks located in the bow control station, shall be possible.

**127** 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.

**128** The control station shall, as a minimum, have two independent systems for communication with other affected control stations, e.g. bridge and shuttle tanker. One of the systems shall be a private and dedicated UHF channel.

**129** The hawser connection should be located as close to the centreline of the unit as practicable.

**130** The minimum distance between the unit and the shuttle tanker shall be sufficient to avoid impact during

offloading operations.

**131** Antennas for the communication between the unit and the shuttle tanker shall be located so that transmission is not disrupted.

OFFSHORE STANDARD
DNV-OS-E201

OIL AND GAS PROCESSING SYSTEMS

CHAPTER 3

# CERTIFICATION AND CLASSIFICATION

CONTENTS PAGE


Sec. 1 Certification and Classification ..... 60
Sec. 2 Design Review ..... 61
Sec. 3 Certification of Equipment ..... 63
Sec. 4 Survey during Construction ..... 68
Sec. 5 Surveys at Commissioning and Start-up ..... 70



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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**

| *No.* | *Title* |
|---|---|
| DNV-OSS-101 | Rules for Classification of Drilling and Support Units |
| DNV-OSS-102 | Rules for Classification of Floating Production, Storage and Loading Units |
| DNV-OSS-309 | Verification, Certification, and Classification of Gas Export and Receiving Terminals |

**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** Offshore terminals fitted with liquefaction or regasification plant 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 **Liquefaction Plant (LNG)** or **Regasification Plant**, respectively.

**203** Offshore units and installations fitted with hydrocarbon offloading systems that have been designed, constructed and installed in accordance with the requirements of Ch.2 Sec.12 of this standard under the supervision of DNV will be entitled to the class notation **OFFLOADING**. 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) Structural design review is limited to the global strength (ULS & ALS) of the special and primary structural members. Review of the methodology for fatigue assessment (FLS) and selection of material will also be included.
3) 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 for design and fabrication shall be in accordance with the NPS DocReq (DNV Nauticus Production System for documentation requirements) and DNV-RP-A201.

**102** Documentation requirements for offshore gas terminals are as given in DNV-OSS-309.

# 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, IB and IC 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 for Cat. IA and IB, 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, IB and IC with the specified requirements as given below.

**Guidance note:**

It should be noted that the scopes defined for category IA, IB and IC 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.

*Category IC:*

— 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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### 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** Offshore terminals fitted with liquefaction or regasification plant 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 **Liquefaction Plant (LNG)** or **Regasification Plant**, respectively.

**203** Offshore units and installations fitted with hydrocarbon offloading systems that have been designed, constructed and installed in accordance with the requirements of Ch.2 Sec.12 of this standard under the supervision of DNV will be entitled to the class notation **OFFLOADING**.

## 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 1)**

| *Property* | *Conditions* | *Category* | |
|---|---|---|---|
| | | I 2) | 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 | $\sigma_y$ 360 MPa (52000 psi) or<br>$\sigma_t$ 515 MPa (75000 psi) | X | |

1) Free standing structural storage tanks will be specially considered based on stored medium, volume and height. These may be designed according to the requirements of Ch.2 Sec.8.

2) 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.

General notes:

For a pressure vessel (e.g. plate heat exchangers) with non circular shape, the Diameter is to be taken as the largest diagonal distance

Categorisation for vessels made of non-ferrous materials are to be decided on a case-by-case basis.

Certification will not cover lifting lugs and lifting points on the equipment.

P = internal design pressure in bar
$D_i$ = inside diameter in mm
V = volume in $m^3$
T = design temperature
$\sigma_y$ = specified yield strength
$\sigma_t$ = specified ultimate tensile strength

**202** Piping is to be designed and fabricated according to the specified piping code. Certification shall affirm compliance with the design code and shall be according to ISO 10474 (EN 10204) Type 3.1 provided the manufacturer has a quality assurance system certified by a competent body.

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

**Table B2 Categories for piping and components**

| *Component* | *Application or rating or description* | *Category* | | |
|---|---|---|---|---|
| | | IA | IB | IC |
| Flow metering- and instrumentation pipe-spools, pig receivers, pig launcher and other special piping items [2)] | Including supports and attachments | X | | |
| Flanges and couplings [1)] | Standard type | | X | X |
| | Non-standard type for high pressure, flammable or toxic fluids | | X | |
| Valves (incl. Choke valves) | Standard valves to recognised standard | | X | X |
| | Valves for Gas & Hydrocarbons (DN ≥ 350mm and P ≥ 100 bar) or (DN ≥ 25 mm and P ≥ 500 bar)[6)] | | X | |
| | Valves for fluids (DN ≥ 25 mm and P ≥ 500 bar[6)] | | | |
| | Non-standard valves | | X | |
| ESD and blow down valves | Including actuator and controls. [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. [4)] | | 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 | | |

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).

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).

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.

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.

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.

6) Otherwise category 2, unless special or unconventional design which is considered category 1B.

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

**Table B3 Categorisation of mechanical equipment**

| *Component* | *Application or rating* | *Category* | | | |
|---|---|---|---|---|---|
| | | IA | IB | IC | II |
| Equipment train or skid | Compressor skid, fire water pump skid, power generation skid etc. 1) | X | | | |
| Pumps 2) | Non-standard design and construction | X | | | |
| | Main production system pumps, export-, booster- and water injection pumps with motor capacity ≥ 300 kW | X | | | |
| | Pumps in hydrocarbon service with motor capacity < 300 kW | | | X | |
| | Fire water pumps5) | | 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 | 3) | | 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 within skids with SWL> 1000 kg. 4) | | X | | |

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.

2) The skidded pump unit may include a number of components which may require individual certification. Pumps in category IC will be accepted by conformation of material, review of fabrication documentation and witness of final functional testing of components.

3) Category for gears, shafts and couplings is to be either IB or II depending on the category of the prime mover.

4) Certification will not cover lifting lugs and lifting points on the equipment itself.

5) Fire water pump (directly driven) is considerd Cat. IB. Fire water lift pump (not directly driven) of proven design may be accepted by conformation of material, witness of testing and review of fabrication documentation.

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

**Table B4 Categorisation of electrical equipment**

| *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 |

**206** Categorisation for off loading systems is to be according to Table B5.

| **Table B5: Categorization of equipment for offloading systems** | | | | |
|---|---|---|---|---|
| *Component* | *Application* | Category | | |
| | | IA | IB | II |
| Hose | | | X | |
| Hose end valve | | X | | |
| Hose reel | | X | | |
| Hawser strong point | | X | | |
| Pneumatic line thrower | | | | X |

## B 300 Miscellaneous items

**301** The categorisation given in Table B6 normally applies for miscellaneous items relating to production plant.

| **Table B6 Categorisation of miscellaneous items** | | | |
|---|---|---|---|
| *Component* | *Category* | | |
| | IA | IB | II |
| Flare booms or towers | X | | |
| Burner | | X | |
| Flare | | X | |
| Cold vents | | X | |
| Tensioning system | X | | |
| Riser | X | | |
| Structural bearings | 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 interconnection 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** The extent of the welding procedure test shall be agreed upon with DNV before the work is started.

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

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

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

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

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

**207** 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.

**208** 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.