

NORSOK STANDARD

COMMON REQUIREMENTS
STRUCTURAL DESIGN

N-CR-001
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Please note that whilst every effort has been made to ensure the accuracy of the NORSOK standards neither OLF nor TBL or any of their members will assume liability for any use thereof.

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1 FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and remove unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and are jointly issued by OLF (The Norwegian Oil Industry Association) and TBL (The Federation of Norwegian Engineering Industries). NORSOK standards are administered by NTS (Norwegian Technology Standards Institution).

The purpose of this industry standard is to replace the individual oil company specifications for use in existing and future petroleum industry developments, subject to the individual company's review and application.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of this standard will be used to provide input to the international standardization process. Subject to implementation into international standards, this NORSOK standard will be withdrawn.

2 SCOPE

The standard specifies general principles and guidelines for the structural design and the structural design verification of loadbearing structures subjected to foreseeable actions.

The standard is applicable to all types of offshore structures used in the petroleum activities, including bottom founded structures as well as floating structures.

The standard is applicable to all types of materials used including steel, concrete, aluminium, etc.

The standard is applicable to the design of complete structures including substructures, topside structures, vessel hulls, foundations, and mooring systems.

The standard specifies design principles which are also applicable to the successive stages in construction (namely fabrication, transportation and installation), to the use of the structure during its intended life, and to its abandonment. Generally, the principles are also applicable to the reassessment or modification of existing structures. Aspects related to verification and quality control are also addressed.

3 NORMATIVE REFERENCES

API RP 2A-LRFD	Recommended practice for planning, designing and constructing fixed offshore platforms - load and resistance factor design.
API RP 2N	Recommended practice for planning, designing and constructing fixed offshore structures in ice environments.
API RP 2SK	Recommended practice for design and analysis of station keeping systems for floating structures.
API RP 2T	Recommended practice for planning, designing and constructing tension leg platforms.

BSI BS 8118	Structural use of Aluminium, Part 1, Code practice for the design of Al-structures.
DNV	Rules for Classification of fixed offshore installations.
DNV	Rules for Classification of mobile offshore units.
DNV	Rules for Classification of ships.
DNV	Classification note no.30.1 "Buckling strength analysis.
DNV	Classification note no.30.2 "Fatigue strength analysis for mobile offshore units.
DNV	Classification note no.30.5 "Environmental conditions and environmental loads.
DNV	Veritas Marine Operations, Standard for insurance warranty surveys in marine operations.
ECCS-26	European recommendations for Aluminum alloy structures.
ECCS-68	European recommendations for Aluminum alloy structures - fatigue design.
ISO 13819-1	Offshore structures Part 1: General requirements.
ISO 3010	Basis for design of structures - seismic action of structures.
NORSOK G-SR-001	Soil investigation.
NORSOK M-CR-101	Structural steel fabrication.
NORSOK M-CR-120	Material data sheets for structural steel.
NORSOK M-CR-501	Surface preparation and protective coating.
NORSOK M-CR-503	Cathodic protection.
NORSOK M-DP-001	Materials selection.
NORSOK S-DP-001	Technical safety.
NORSOK U-CR-001	Subsea structures and piping systems.
NORSOK Z-CR-001	Documentation for operation.
NPD	Regulations relating to loadbearing structures in the petroleum activities.
NPD	Guidelines to regulations relating to loadbearing structures in the petroleum activities.
NPD	Guidelines concerning to loads and load effects.
NPD	Guidelines on design and analysis of steel structures.
NPD	Guidelines on selection of steels and fabrication of steel structures.
NPD	Guidelines for structural design of aluminum structures.
NPD	Guidelines relating to concrete structures.
NPD	Guidelines on condition monitoring of loadbearing structures.
NPD	Regulations relating to implementation and use of risk analysis in the petroleum activities.
NS 3471	Aluminum structures. Design rules.
NS 3472	Steel structures. Design rules.
NS 3473	Concrete structures, Design rules.
NS 3481	Soil investigation and geotechnical design for marine structures.
NS 2128	Weights engineering, Terminology.
NS 2129	Weights engineering, Requirements for weight reports.
NS 2130	Weights engineering, Specification for weighing of major assemblies.

NS 2131 Weights engineering, Specification for weight data from suppliers and weighing of bulk and equipment.

4 DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

Normative references	Shall mean normative in the application of NORSOK standards.
Informative references	Shall mean informative in the application of NORSOK standards.
Shall	Shall is an absolute requirement which shall be followed strictly in order to conform with the standard.
Should	Should is a recommendation. Alternative solutions having the same functionality and quality are acceptable.
May	May indicates a course of action that is permissible within the limits of the standard (a permission).
Can	Can-requirements are conditional and indicates a possibility open to the user of the standard.
Design Premises	A set of project specific design data and functional requirements which are not specified or are left open in the general standard.
Norwegian petroleum activities	Petroleum activities where Norwegian regulations apply.
Operator	A company or an association which through the granting of a production licence is responsible for the day to day activities carried out in accordance with the licence
Petroleum activities	Offshore drilling, production, treatment and storage of hydrocarbons.
Principal Standard	A standard with higher priority than other similar standards. Similar standards may be used as supplements, but not as alternatives to the Principal Standard.
Recognized classification society	A classification society with recognized and relevant competence and experience from the petroleum activities, and established rules and procedures for classification/certification of installations used in the petroleum activities.
Verification	Examination to confirm that an activity, a product or a service is in accordance with specified requirements.

4.2 Abbreviations

API American Petroleum Institute.

BSI	British Standards Institution.
DNV	Det Norske Veritas.
ECCS	European Convention for Constructional Steelwork.
ISO	International Organization for Standardisation.
NPD	Norwegian Petroleum Directorate.
NS	Norsk Standard.

5 GENERAL PROVISIONS AND DESIGN PRINCIPLES

5.1 Regulations, standards and design premises

Loadbearing structures used in the petroleum activities shall comply with relevant national and international regulations. The Principal Standard for design of offshore structures is ISO 13819-1.

Load coefficients, material coefficients, design fatigue factors and rules for combination of loads shall be determined on the basis of relevant national or international requirements with regard to reliability. All design of loadbearing structures in the Norwegian petroleum activities shall comply with NPD: Regulations relating to loadbearing structures in the petroleum activities.

When the rules of a classification society are used as basis for design and documentation, possible additional requirements necessary to fulfil relevant national regulations shall be identified and implemented. A Class Notation should be specified with the objective to minimize the need for additional requirements.

A Design Premises document shall be prepared and used as basis for design and documentation, stating all project specific regulations, standards, and functional requirements.

5.2 Risk assessment

Risk assessments shall be carried out in order to identify accidental events that may occur in the activities, and the consequences of such events for people, for the environment and for assets and financial interests. The extent of risk assessments and the risk assessment methods shall be determined by the Operator, taking into account the type of structure and relevant accumulated experience.

Note:

For the Norwegian petroleum activities risk analysis shall comply with NPD: Regulations relating to implementation and use of risk analysis in the petroleum activities.

5.3 Requirements and guidelines for design and materials selection

Requirements and guidelines for calculation of loads and load effects are given in clause 7.

Requirements and guidelines for general design of structures are given in clause 8.

Requirements and guidelines for design of specific types of structures are given in clause 9.

The Principal Standard for selection of materials is NORSOK M-DP-001 Materials selection.

5.4 Reassessment of existing structures

Principles for reassessment of existing structures are given in ISO 13819-1. Structural analysis and verification shall be carried out in accordance with the relevant design standards and guidelines,

taking into consideration the accumulated operational experience and the standard to which the installation was originally designed.

5.5 Abandonment

The abandonment and final disposal of the facilities shall be considered at the design stage, and to the extent required by the Operator. An abandonment dossier, containing details of the installation and other aspects which may influence the final disposal of the facilities, should be prepared.

6 INDEPENDENT VERIFICATION

6.1 Requirements for verification

It shall be verified that provisions contained in relevant national and international regulations or decisions made pursuant to such regulations, have been complied with.

The extent of the verification and the verification method in the various phases shall be assessed. The consequences of any failure or defects that may occur during construction of the structure and its anticipated use shall receive particular attention in this assessment.

The verification shall confirm whether the structure satisfies the requirements for the specific location and method of operation, taking into consideration the design, including material selection and corrosion protection, and the analyses methods used.

Further requirements and guidelines for structural design verification of loadbearing structures in the Norwegian petroleum activities are given in NPD: Regulations relating to loadbearing structures in the petroleum activities and NPD: Guidelines to regulations relating to loadbearing structures in the petroleum activities.

Note:

According to Norwegian regulations it is an obligation for the Operator to perform the verification.

6.2 Verification methods

The verification shall be carried out as a combination of independent calculations, document review and audits (both technical and system audits) as appropriate. Particular emphasis shall be put on the verification of the design of structures or structural parts of significance to the overall safety.

The verification calculations shall be sufficiently accurate and extensive to clearly demonstrate that the dimensions are adequate. Such calculations may be manual calculations or computer calculations. Software used in verification shall have been checked for the purpose in question.

6.3 Organization and documentation

There shall be organizational independence between those who carry out the design work, and those who verify it. Special consideration should be given to the organization of verification activities in cases where new project execution models and/or information technology systems are introduced.

Verification shall be documented. Certificates issued by a national authority or a recognized classification society may be used as documentation, provided the acceptance criteria used as basis for the certificates have been verified. Possible additional requirements to meet relevant national regulations shall be identified and implemented.

7 LOADS AND LOAD EFFECTS

7.1 General

Loads and load effects to be considered are defined in ISO 13819-1. The Principal Standard for calculation of loads and load effects should be NPD: Guidelines concerning to loads and load effects. Design data should be determined from actual measurements at the site or by suitable validated model data such as from hindcast models. Such design data shall be stated in the Design Premises.

Other standards and guidelines such as DNV: Classification note no.30.5, API RP 2N and ISO 3010 may be used as supplements to the Principal Standard. The use of such supplementary standards should depend on type of structure, location and relevant accumulated experience.

7.2 Characteristic wave loads and load effects

Characteristic wave loads and load effects for design purposes can be obtained by a long term analysis, a short term analysis or a design wave analysis.

The most general approach is using long term analysis. If however, a short term consideration is used, it should be ensured that the selected short term sea state yields most probable largest loads and load effects that correspond to the target return period for the specific area in question. Such a requirement can be met by exposing the structure to a set of short term sea states. This set shall be determined such that for the most unfavourable sea state of this set, the most probable largest value of a given load or load effect represents an adequate estimate for the 100-year value.

For the North Sea and Norwegian Sea type of wave climate, such a set of sea states is represented by a contour line of the joint probability density function for the significant wave height and the spectral peak period, i.e. the same density function that is used in a long term response analysis.

Adopting 3 hours for the duration of the short term sea state, a proper contour line is obtained by requiring the largest value of the significant wave height along the contour line to be 10% larger than the marginal 100-year value. An example of such a contour line is shown in fig. 1.

Note:

The contour line concept can be extended to include other environmental parameters, e.g. wind and current.

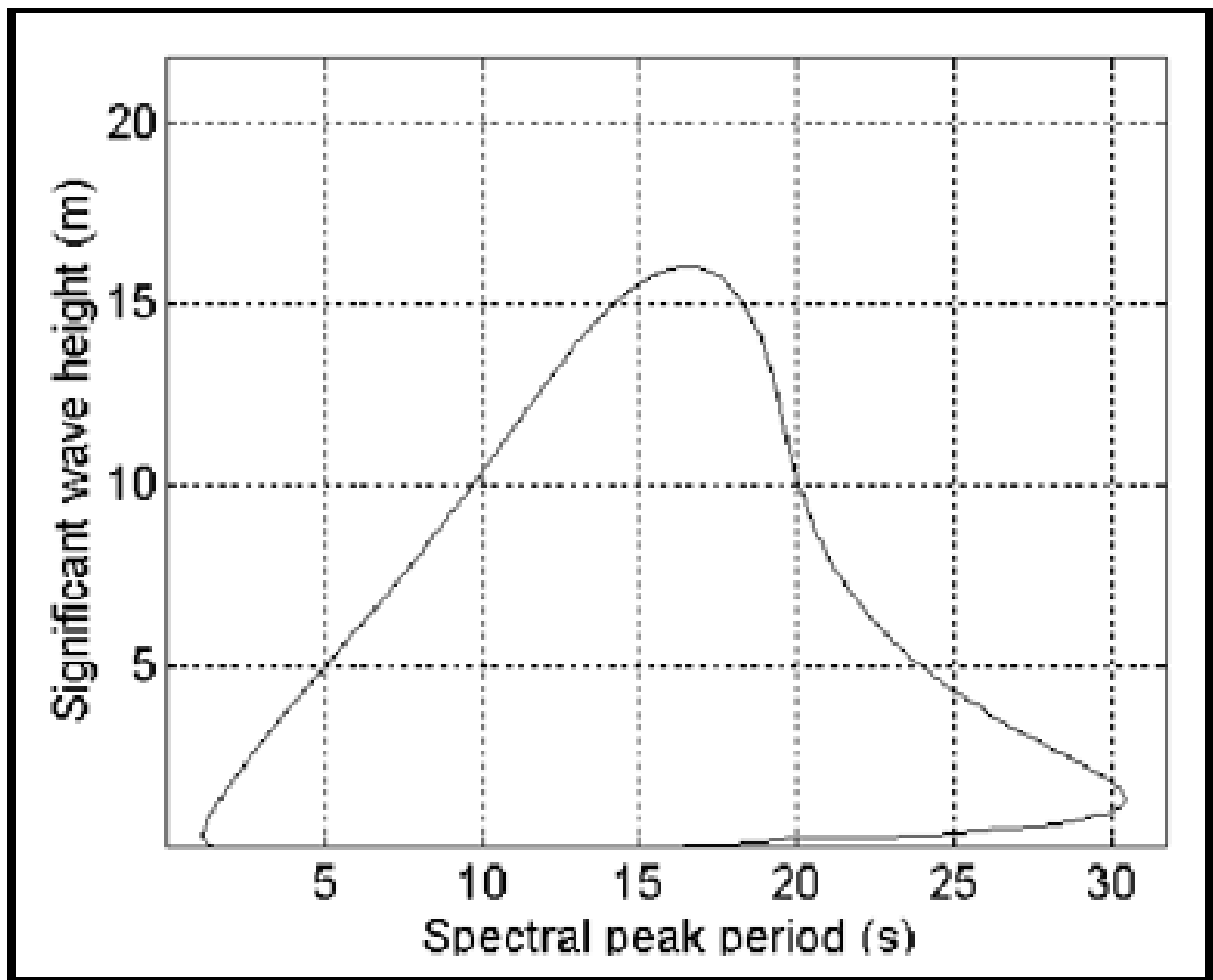


Fig. 1 Example contour line

Hydrodynamic loads and load effects due to waves and current may be determined from:

- Design wave analysis.
- Linearized probabilistic analysis.
- Time domain analysis.

Appropriate drag and inertia coefficients for the selected method shall be stated in the Design Premises.

7.3 Special considerations

7.3.1 Deck elevation

The topside structure shall normally have adequate clearance above the design wave crest. When determining the deck elevation and air gap in accordance with ISO 13819-1, the non-Gaussian structure of surface waves shall be accounted for. Any topside structure or piping not having adequate clearance shall be designed for actions caused by waves and currents. Impact loads should be verified by properly designed model tests. Minor structure or components may be excluded from this requirement.

7.3.2 Dynamic loading and fatigue in topside structures

The possibility for dynamic loading and fatigue damage in topside structures shall be considered.

Dynamic loading and fatigue damage may be significant, e.g. in case of:

- Interaction between topside structures and multi-shaft fixed concrete substructures.
- Interaction between topside structures and column/pontoon type floating substructures.
- Interaction between topside structures and monohulls (global hull bending).
- Wave induced motions and accelerations of floating structures.
- Direct wave loads (slamming).

Flare towers, drilling towers, bridges, crane pedestals etc. should be given special attention.

7.3.3 Variable functional deck loads

Variable functional loads on deck areas of the topside structure shall be based on table 1 unless specified otherwise in the Design Premises. The load intensity of the distributed load depends on local/global aspects as shown in table 1. The following notations are used:

Local design	Design of plates and stiffeners.
Primary design	Design of girders and columns.
Global design	Design of deck main structure and substructure.

Table 1 Variable functional deck loads

Area	Local design		Primary design	Global design
	Distributed load, p	Point load, P	Apply factor to distributed load	Apply factor to primary design load
	P (kN/m ²)	P (kN)		
Storage areas	q	1.5 q	1.0	1.0
Laydown areas	q	1.5 q	f	1.0
Lifeboat platforms	9.00	9.00	1.0	may be ignored
Area between equipment	5.00	5.00	f	may be ignored
Walkways, staircases and platforms	4.00	4.00	f	may be ignored
Walkways and staircases for inspection and repair only	3.00	3.00	f	may be ignored
Roofs, accessible for inspection and repair only	1.00	2.00	1.0	may be ignored

Notes:

1. Wheel loads to be added to distributed loads where relevant. (Wheel loads can normally be considered acting on an area of 300 x 300mm.)
2. Point loads to be applied on an area 100 x 100mm, and at the most severe position, but not added to wheel loads or distributed loads.
3. q to be evaluated for each case. Laydown areas not normally to be designed for less than 15kN/m²
4. $f = \min\{1,0 ; (0,5 + 3/A^{0,5})\}$, where A is the loaded area in m².

7.3.4 *Weights engineering and weight control*

For verification of design loads assumptions a system for weights engineering and weight control, based on NS 2128, NS 2129, NS 2130 and NS 2131, should be established and implemented.

7.3.5 *Accidental loads and protection against accidental loads*

Reference is made to NORSOK S-DP-001, Technical safety.

7.3.6 *Anomalous dynamic effects*

Ringling and springing dynamic effects need to be carefully taken into account in design of e.g. tension leg platforms and gravity based structures. Where analytical approaches are not fully developed/acknowledged, it is a requirement to perform model testing at appropriate scale.

8 GENERAL DESIGN

8.1 Design objectives

A structural system, its components and details shall be designed to comply with ISO 13819-1 and the following listed principles:

- Structures and structural elements, shall have ductile resistance unless the specified purpose or the structural material requires otherwise.
- Structures shall be designed such that an unintended event do not escalate into an accident of significantly greater extent than the original event.
- Structures shall be designed with the objective to minimize stress concentrations and provide a simple stress path.
- Structures shall be designed such that fabrication, including surface treatment, can be accomplished in accordance with relevant recognized techniques and practices.
- Design of structural details, selection of structural profiles and use of materials shall be done with the objective to minimize corrosion and the need for special precautions to prevent corrosion.
- Adequate access for inspection, surveillance, maintenance and repair shall be provided.
- Satisfy functional requirements as given in the Design Premises.

Structures shall be designed with due consideration to fire, explosions, impacts, flooding and other relevant accidental events with associated effects. In assessing the risk for accidental events, technical, operational and/or organizational risk reducing measures should be considered, see also NORSOK S-DP-001, Technical safety.

Criteria related to elastic displacements and vibrations shall be established and evaluated for the serviceability limit state. Such criteria shall be stated in the Design Premises.

Notes:

1. The vertical deflection of horizontal members should not exceed $L/250$, where L is the span of the member. For members supporting pipes or mechanical equipment other criteria may have to be implemented.
2. Commonly used design methods are based on the assumption that design values for load effect and resistance can be calculated separately. In cases where integrated non-linear analyses are used, care should be taken to ensure that equivalent levels of safety are obtained.

8.2 Design of steel structures

8.2.1 Design

The Principal Standards for design of steel structures should be NPD: Guidelines on design and analysis of steel structures and NS 3472.

The principles of steel structural design are established on the premises of satisfactory element strength and ductility in all failure modes to be checked, coupled with the desire for system ductility and redundancy in design.

Other design standards and guidelines, such as DNV: Classification notes no.30.1 and no.30.2, may be used as supplements to the Principal Standards specified above. The use of such supplementary standards should depend on type of structure, location and relevant accumulated experience.

8.2.2 Material selection and requirements for non-destructive testing

8.2.2.1 Design class

Selection of steel quality and requirements for inspection of welds shall be based on a systematic classification of welded joints according to the structural significance and complexity of joints.

The main criteria for decision of design class (DC) of welded joints are the significance with respect to global integrity, the consequences of failure, the degree of redundancy and the stress predictability (complexity). The selection of joint design class shall be in compliance with table 2.

Notes:

1. DC1 should be considered as a special case selection, applicable for complex joints, including joints with tensile through-thickness stresses, which would otherwise have been classified as DC2. Typical examples: top of jacket main legs and critical transitions, topside footing connections, topside footings to main truss members, critical transitions in hulls and main steel joints with high fatigue utilisation
2. DC2 should be used for the majority of joints which are essential for the overall integrity of the installation, and for special details of high importance for local integrity and safety (crane pedestals, bridge supports, flare tower supports, lifting beams, pad-eyes etc.)
3. DC3 should be considered as a special case selection, applicable for complex joints, including joints with tensile through-thickness stresses, which would otherwise have been classified as DC4.
4. DC4 should be used for the majority of structural joints significant for local structural integrity, i.e. joints in trusses, bulkheads, decks, stiffeners, braces, large pipe supports and equipment supports.

8.2.2.2 Steel quality level

Selection of steel quality level for a structural component shall normally be based on the most stringent DC of joints involving the component. Through-thickness stresses and low temperature toughness requirements shall be assessed.

The minimum requirements for the steel quality level to be selected are found in table 2. Selection of a better steel quality in procurement or fabrication than the minimum required in design shall not lead to more stringent requirements in fabrication.

The Principal Standard for specification of steels is NORSOK M-CR-120, Material data sheets for structural steel.

If steels of higher yield strength than 500MPa or greater thickness than 150mm is selected, the feasibility of such a selection shall be assessed in each case.

Traceability of materials shall be in accordance with NORSOK Z-CR-001, Documentation for operation.

8.2.2.3 Welding and non-destructive testing

The extent of non-destructive examination during fabrication of structural joints shall be in compliance with the dedicated inspection category. The selection of inspection category for each welded joint shall be in accordance with table 3.

The Principal Standard for welding and non-destructive testing is NORSOK M-CR-101, Structural steel fabrication.

Table 2 Classification of structural joints and components

Design Class	Criteria for Selection of Design Class
DC1	Joints and components essential for total load capacity, with low redundancy or complex form and complex stress conditions. This includes three-dimensional stresses/tensile stress in through-thickness direction/high degree of restraint/unpredictable detail stress distribution.
DC2	Joints and components essential for total load capacity, with simple form and predictable stress distribution.
DC3	Joints and components significant for local load capacity, with complex form and complex stress conditions. This includes combinations of three-dimensional stresses/tensile stress in through-thickness direction/high degree of restraint/unpredictable stress distribution.
DC4	Joints and components significant for local load capacity, with simple form and predictable stress distribution.
DC5	Joints and components in less significant load bearing structures.

Table 3 Correlation between design classes and steel quality level

Design Class	Steel Quality Level			
	I	II	III	IV
DC1	X			
DC2		X		
DC3	(X)	X		
DC4			X	
DC5				X

(X) = Selection when there is tensile stress in the direction of thickness.

Table 4 Determination of inspection category for joints subjected to static loads and low fatigue stress

Design Class	Type of stress, level and direction in relation to welded joint	Inspection category
DC1 & DC2	Welds subjected to normal stress transverse to typical (possible) defects	A
	Welds that mainly transmit shear and welds subjected low normal stress transverse to typical defects.	B
	Welds that transmit shear only.	C
DC3	Welds subjected to normal stress transverse to typical defects.	B
	Welds that mainly transmit shear and welds subjected to moderate stress only transverse to typical defects.	C
DC4	Welds subjected to normal stress transverse to typical defects.	C
	Welds that mainly transmit shear and welds subjected to moderate stress only transverse to typical defects.	D
DC5	All load-bearing joints.	D
	Non load-bearing joints.	E

8.3 Design of aluminium structures

The Principal Standards for design of aluminium structures should be NPD: Guidelines for structural design of aluminum structures, NS 3471 and ECCS-68.

Note: NS3471 is not fully updated to current state-of-art, in particular with respect to fatigue. Design against fatigue shall therefore be done in accordance with ECCS-68.

Other design standards and guidelines such as ECCS-26 and BSI: BS 8118 may be used as supplements to the Principal Standards specified above. The use of such supplementary standards should depend on type of structure, location and relevant accumulated experience.

Selection of aluminium quality and requirements for inspection of welds shall be based on a systematic classification of welded joints according to the structural significance and complexity of joints as described in clause 8.2 for steel structures.

8.4 Design of concrete structures

The Principal Standards for design of concrete structures should be NPD: Guidelines relating to concrete structures and NS 3473.

Note: The above mentioned standards are not fully updated to current state-of-art, in particular with respect to functional requirements for offshore platforms. Functional requirements relevant to a special design shall be stated in the Design Premises.

Other design standards and guidelines, such as DNV: Rules for classification of fixed offshore installations, may be used as supplements to the Principal Standards specified above. The use of such supplementary standards should depend on type of structure, location and relevant accumulated experience.

8.5 Geotechnical design for marine structures

The geotechnical design for marine structures shall comply with the principles given in ISO 13819-1. The Principal Standard for soil investigation should be NORSOK G-SR-001, "Soil investigation", and the Principal Standard for geotechnical design should be NS 3481.

Other design standards and guidelines, such as API RP 2A-LRFD and DNV: Rules for Classification of fixed offshore installations, may be used as supplements to the Principal Standards specified above. The use of such supplementary standards should depend on type of structure, location and relevant accumulated experience.

8.6 Marine operations

For operations where a Marine Warranty Surveyor has been appointed to fulfil the clauses in the insurance policy, all requirements given by the Marine Warranty Surveyor shall be complied with. For operations where a Marine Warranty Surveyor has not been appointed the DNV: Veritas marine operations, Standard for insurance warranty surveys in marine operations should be applied.

8.7 Condition monitoring of structures

The Principal Standard for planning and implementation of a condition monitoring system of load bearing structures should be NPD: Guidelines on condition monitoring of loadbearing structures. Special consideration shall be given to critical components identified on the basis of risk assessment, operating experience and failure statistics.

A Design, Fabrication and Installation resume (DFI-resume) shall be prepared in accordance with the appendix of the guidelines.

8.8 Corrosion protection of structures

The site specific conditions and the planned degree of weather protection shall be considered with regard to corrosion, and a suitable corrosion protection system shall be designed. If the conditions differ significantly from previous experience, field measurements should be carried out.

Adequate accessibility for corrosion protection and maintenance shall be allowed for in the design.

The Principal Standards for planning and implementation of a corrosion protection system for load bearing structures should be NORSOK: M-DP-001, Materials selection, NORSOK: M-CR-501, Surface preparation and protective coating and NORSOK: M-CR-503, Cathodic protection.

Other design standards and guidelines may be used as supplements to the Principal Standards specified above. The use of such supplementary standards should depend on type of structure, area of location and relevant accumulated experience.

Consistency between structural design criteria, technical solutions and applied corrosion protection system shall be documented.

9 DESIGN OF VARIOUS TYPES OF STRUCTURES

9.1 Fixed steel structures

Fixed steel structures (steel jackets) should be designed and verified in accordance with clauses 5 - 8 of this standard. Other design standards and guidelines, such as API RP 2A-LRFD and DNV: Rules for classification of fixed offshore installations may be used as supplements.

9.1.1 Integrated design

The substructure should be designed integrated with the superstructure (topside) and the soil foundation.

9.1.2 Fatigue design

Structures shall be designed with the objective to minimize life cycle costs, taking into account the need for in-service inspection, maintenance and repair. Assumptions made regarding accessibility and design fatigue factors shall be stated in the Design Premises.

9.1.3 Tubular joints design

Finite element analysis should be used in the design of complex and/or critical joints.

9.1.4 Temporary phases

Vortex induced vibrations during fabrication, transport and installation shall be taken into account. Vortex reducing devices may be considered.

9.2 Fixed concrete structures

Fixed concrete structures should be designed and verified in accordance with clauses 5 - 8 of this standard.

The soil-structure interaction shall be carefully assessed in the calculation of soil reactions for the design of the structure including skirts, dowels etc. Realistic upper and lower bounds of soil parameters shall be assumed so as to ensure that all realistic patterns of soil reactions are enveloped in an appropriate manner. As part of this degree of mobilization both locally and globally shall be considered as well as plasticity at stress peaks and time dependent effects. Skirt compartments that in the design are assumed to rely on pore pressure higher than ambient, shall be documented to have the appropriate tightness for all limit states.

9.3 Tension Leg Platforms

Tension Leg Platforms including topside structures and tether system, should be designed and verified in accordance with clauses 5 - 8 of this standard. Other design standards and guidelines, such as DNV: Rules for classification of fixed offshore installations and API RP 2T may be used as supplements.

9.4 Column Stabilized Units

Column Stabilized Units (semisubmersibles) including topside structures and station keeping system, should be designed and verified in accordance with clauses 5 - 7 of this standard in combination with the rules of a recognized classification society. For the Norwegian petroleum activities the DNV: Rules for classification of mobile offshore units should be applied. The relevant Class Notation shall be stated in the Design Premises.

Relevant parts of clause 8 of this standard and other recognized standards, such as API RP 2SK, may be used as supplements.

9.5 Self-Elevating Units

Self-Elevating Units (jack-ups) including topside structures, should be designed and verified in accordance with clauses 5 - 7 of this standard in combination with the rules of a recognized classification society. For the Norwegian petroleum activities the DNV: Rules for classification of mobile offshore units" should be applied. The relevant Class Notation shall be stated in the Design Premises.

Relevant parts of clause 8 of this standard and other recognized standards may be used as supplements.

9.6 Ship-shaped Units

Ship-shaped Units (ships, barges) including topside structures and station keeping system, should be designed and verified in accordance with clauses 5 - 7 of this standard in combination with the rules of a recognized classification society. For the Norwegian petroleum activities the DNV: Rules for classification of ships should be applied. The relevant Class Notation shall be stated in the Design Premises.

Relevant parts of clause 8 of this standard and other recognized standards, such as API RP 2SK, may be used as supplements.

9.7 Topside structures

Topside structures (integrated decks, module support frames, modules and equipment skids) should be designed and verified in accordance with clauses 5 - 8 of this standard, or the relevant rules of a recognized classification society, as stated in clauses 9.3 - 9.6 of this standard.

9.8 Helicopter decks

Helicopter decks for installations used in the petroleum activities shall be designed and verified in accordance with relevant national or international regulations.

The structural design of helicopter decks should be in accordance with the DNV: Rules for classification of mobile offshore units or DNV: Rules for classification of ships.

9.9 Flare Towers

Flare towers should be designed and verified in accordance with clauses 5 - 8 of this standard. Other design standards and guidelines, such as DNV: Rules for classification of fixed offshore installations may be used as supplements.

9.9.1 Vortex induced vibrations

Displacements and fatigue damage caused by vortex induced vibrations, including wake interactions, local frame vibrations and global vibrations, should be considered.

Flare towers should preferably be designed with the objective to avoid vortex induced vibrations. Permissible design ranges based on critical velocities may be utilised.

Alternatively, flare towers may be designed according to relevant fatigue criteria, taking into account the accumulated damage caused by vortex induced local vibrations and global dynamic response.

In special cases, e.g. temporary phases, the use of vortex reducing devices may be considered.

9.10 Offshore Loading Buoys

Offshore loading buoys should be designed and verified in accordance with clauses 5 - 7 of this standard in combination with the rules of a recognized classification society. For the Norwegian petroleum activities the DNV: Rules for classification of mobile offshore units should be applied. The relevant Class Notation shall be stated in the Design Premises.

Relevant parts of clause 8 or other recognized standards may be used as supplements.

9.11 Subsea structures

Subsea structures should be designed and verified in accordance with the principles for general design of structures (clauses 5-8 of this standard) and NORSOK: U-CR-001, Subsea structures and piping systems.

9.11.1 Fatigue assessment

Dynamic loading and fatigue should in particular be considered in the design of subsea structures that are connected to surface structures by mooring lines, cables or risers.