

NORSOK STANDARD

CONDITION MONITORING OF LOADBEARING STRUCTURES

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FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and eliminate 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 supported by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Engineering Industries). NORSOK standards are administered and issued by NTS (Norwegian Technology Standards Institution).

The purpose of NORSOK standards is to contribute to meet the NORSOK goals, e.g. by replacing individual oil company specifications and other industry guidelines and documents for use in existing and future petroleum industry developments.

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 Subject to implementation into international standards, the NORSOK standard will be withdrawn.

Annex A and B are informative. Annexes C, D, E and F hereof are normative.

INTRODUCTION

This NORSOK standard focuses on adopting life cycle approach considering safety and cost related issues throughout the design, construction, operation and final disposal of offshore structures. The requirements specified hereof are however not necessarily applicable for the phases beyond decommissioning of an installation. The effects on DFI activities, including cost increases due to efforts to reduce IMR expenditure, should be considered against the IMR related aspects in operation phase. A key issue in this context is to retain the possibility of using safe and cost effective inspection methods.

This standard describes principles of how condition monitoring of loadbearing structures should be planned, implemented and documented to maintain a safe installation and to comply with the NPD regulations including the requirements in the relevant standards.

1 SCOPE

This NORSOK standard describes principles, functional requirements and guidelines for condition monitoring of the loadbearing structures throughout their operative lifetime until the decommissioning. 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 condition monitoring of complete structures including substructures, topside structures, vessel hulls, foundations, and mooring systems.

The standard covers all aspects related to condition monitoring, including in-service inspection and maintenance planning, implementation, structural integrity evaluation, condition monitoring documentation. Assessment of offshore structures, when the initiators exist, is also addressed.

2 NORMATIVE REFERENCES

The following standards include provisions which, through reference in this text, constitute provisions of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet or exceed the requirements of the standards referenced below.

ISO 13819-1	Offshore structures part 1: General requirements
EN 473	Qualification and certification of NDT personnel - General principles
NORSOK N-001	Structural design
NORSOK N-002	Collection of metocean data
NORSOK Z-001	Documentation for operation (DFO)

3 DEFINITIONS AND ABBREVIATIONS

3.1 Definitions

Acceptable damaged condition	Acceptable damaged condition is a condition where there may be for example damage to the installation's loadbearing structures, but which based on a detailed evaluation or assessment may be justified for further operation on certain conditions, such as monitoring, repairs within a stipulated time limit or with operational limitations.
Atmospheric zone	That part of the loadbearing structures which normally is not subjected to repeated sea water wetting and drying.
Can	Can requirements are conditional and indicates a possibility open to the user of the standard.

Company	The operating company of an offshore installation.
Condition monitoring	Systematic examination and evaluation of the overall structural condition ensuring that an acceptable level of structural integrity and safety is maintained.
Condition report	Documented results from condition monitoring.
Condition summary	Description of the condition of the loadbearing structures in the operational phase.
Contractor	The company to design, fabricate or install complete or parts of an offshore installation.
Deviation	Lack of accordance between actual condition and regulatory requirements, industry requirements, internal Company requirements, the design condition, or the intended use.
DFI resumé	Design, fabrication and installation resumé, developed in accordance with the Company condition monitoring philosophy and NORSOK Z-001 DFO.
General damages	Corrosion, visible cracks, dents, gouges, abrasion, deformations, etc.
Gross damages	Large deformations, severed joints, missing member, etc.
Informative references	Shall mean informative in the application of NORSOK standards.
Loadbearing structures	Those part of an installation that have transfer of actions as their main objective, such as substructure of bottom founded structures, gravity base structures, hull of floating units, bridges, deck structures, drilling derricks, flare booms, crane pedestals, helideck structures, lifeboat platforms, riser support systems, mooring systems, etc.
May	May indicates a course of action that is permissible within the limits of the standard (a permission).
Normative references	Shall mean normative in the application of NORSOK standards.
Norwegian petroleum activities	Petroleum activities where Norwegian regulations apply.
Operator	A company or an association which through the granting of a production license is responsible for the day to day activities carried out in accordance with the license

Periodic activities	The activities to be performed on a regular basis.
Petroleum activities	Offshore drilling and production, treatment, and storage of hydrocarbons.
Phase	The relevant stage applicable to each individual installation: design, construction, operation, decommissioning and final disposal.
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.
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.
Signs of gross damages	Gaps, spalling of marine growth or surface coating, etc.
Splash zone	That part of the loadbearing structures which is subjected to repeated sea water wetting and drying.
Structural integrity	Structural soundness and strength, stability, buoyancy in so far as they are relevant to life safety, the environment, and substantial economic values.
Submerged zone	That part of the loadbearing structures which normally is submerged in sea water and exposed to the constant influence of this element.
Unacceptable damaged condition	Unacceptable damaged conditions is a condition which involves major damages significant to the structural integrity and which, throughout different levels of assessment, has been identified as noncompliant to the prevailing regulations. This condition is not acceptable for further operation.

3.2 Abbreviations

ACFM	Alternating current field measurement
ACPD	Alternating current potential drop
CP	Cathodic potential
CSU	Column Stabilized Unit
DFI	Design, fabrication and installation
Dff	Design fatigue factor
DP	Dynamic Positioning

EC	Eddy current inspection
IBCM	Instrumentation Based Condition Monitoring
IMR	In-service Inspection, Maintenance and Repair
ISO	International Organization for Standardisation
MPE	Magnetic particle examination
NDE	Non-Destructive Examination
NPD	Norwegian Petroleum Directorate
PDO	Plan for Development and Operation
ROV	Remotely Operated Vehicle

4 GENERAL

4.1 Objectives

The objectives of condition monitoring for loadbearing structures are to ensure that an adequate level of structural integrity is maintained at all times.

4.2 Regulations, standards and premises

Loadbearing structures used in petroleum activities shall throughout their lifetime comply with relevant national and international regulations. The loadbearing structures should be inspected, evaluated, assessed and maintained, in line with this standard and ISO 13819-1 "Offshore structures, Part 1: General requirements".

The loadbearing structures shall at all times meet the intent of the standards to which they were originally designed.

The condition monitoring philosophy provided by the Company shall be applied as a part of the design premises.

A certificate granted by a recognised classification society, based on the classification rules and offshore survey may be accepted as a verification of the condition, provided that the classification rules applied satisfy requirements as specified in the regulations, the normative standards inclusive this standard, and other applicable documents. The same requirements are also applicable to re-qualification of fitness for an offshore installation dependent on if the installation fulfils the requirements at the date of PDO.

When the verification of structural condition is based on the rules and services of a classification society without issuance of maritime certificates, the requirements to structural condition monitoring and documentation should be in accordance with the regulations and this standard. The Classification society will in this case be regarded as a technical consultant for the Operator. The Operator has the responsibility towards the authorities.

4.3 Condition monitoring principles

The Operator shall throughout the lifetime of the installation ensure that the loadbearing structures are suitable for the intended purpose.

The Operator shall monitor the condition of the operated offshore installation in a systematic manner. This may include development of an overall philosophy and strategy for condition

monitoring, establishing in-service inspection systems and long term inspection programs, in-service inspection planning, offshore execution, data logging, evaluation and assessment, implementation of repair and mitigation measures, emergency preparedness, etc.

The structural integrity may be considered based on component check, system capability assessment or / and system safety assessment.

Note: For petroleum activities on the Norwegian Continental Shelf, the systems' loadbearing capabilities shall be in accordance with the Regulations related to loadbearing structures. Deviations from the above-mentioned regulations, e.g. the use of system capability assessment or/and system safety assessment methods, is regarded as a deviation from the regulations and requires an exemption from the NPD.

In order to achieve the objectives as described in subclause 4.1, the condition monitoring shall determine, within a reasonable level of confidence, the existence, extent and consequence of:

- degradation or deterioration due to fatigue or other time dependent structural damage
- corrosion damage
- fabrication or installation damage
- damage or component weakening due to strength overloading
- damage due to man-made hazards
- excessive deformations

and for floating units specially:

- violating requirements to intact stability
- defects on watertight doors, hatches, automatic shutting functions, onboard warning system
- defect on ballasting system, tank sounding, valves, pumps, etc.
- damage of mooring system

Areas of concern shall be:

- human life and health
- the environment
- properties, operating interests and other economic aspects.

The condition monitoring programme is subject to continuous updating as it involves many factors in the nature of uncertainty such as environmental conditions, failure probabilities, damage development, etc. In addition, a revision of the programme may also be necessary as a result of development of tools and methods.

In case the condition of an offshore installation is monitored adopting other principles, the Operator shall be able to document that requirements to structural integrity and other functional requirements are met.

4.4 Technical documentation

The Operator shall be able to document the system and acceptance criteria applied to in-service inspection planning, offshore execution, result evaluation and assessment, and emergency

preparedness for structural damage in connection with extreme conditions and accidents, and reporting routines. The documentation, including relevant procedures of different levels, shall be available to the authorities as requested.

Computer programs to be used in condition monitoring of offshore loadbearing structures shall be documented to show that they are suitable for their intended purposes and that they are properly verified.

For mobile installations registered in a state's shipping register and certified by a recognized classification society, it should be documented that condition of the structure, during its use in the petroleum activities, complies with the requirements of the legislation enforced by the national authorities. In case of non-conformance, the deviation, its significance and plan for implementation of necessary corrective measures shall be reported to the authority as required.

4.4.1 IMR design requirements

A condition monitoring philosophy document shall be provided by the Company as stated in subclause 4.3.

This document shall contain the Operator's condition monitoring philosophy, applied inspection methods, access requirements, limitations of inspection related to safety and operations, and corresponding design requirements such as corrosion allowance, corrosion protection, specific fatigue requirements, etc. Any additional requirements regarding DFI information may also be addressed in this document.

This philosophy document shall be used as a part of the design basis for the loadbearing structure.

4.4.2 IMR design brief and design report

The design Contractor shall in the design brief implement Operator's IMR design requirements and requirements in this standard and demonstrate how the requirements can be met by the design. The design brief shall cover, as a minimum, the areas such as overall structural redundancy, provisions of critical areas and components, consequences of failures, accessibility, possible repair methods, extent of inspection and inspection methods which are premised for the design.

An IMR design report shall be prepared by the design Contractor accordingly.

4.4.3 DFI resumé

A summary document containing key technical information and with reference to all relevant DFI documents shall be prepared in parallel to the other works during the design and construction. The information should include design basis, condition monitoring concept, areas of vital importance to the structural integrity and functional performance, deviations, and the other as-built data significant to developing condition monitoring programme and to the uses in the operation phase.

Requirements to the DFI resumé, are detailed in NORSOK Z-001 "Documentation for operation (DFO)", Annex A.7 DFI resumé and Annex C DFI resumé for loadbearing structures.

Regarding deviations, distinction should be made between deviations from the regulations, Company's project specific requirements, relevant codes and standards, professional publications, construction non-conformance, and other deviations from the conditions reported in the design reports. Particular attention should be given to any parts of installation's loadbearing structures that

have been damaged or repaired during construction phases and which may be significant to the structural integrity and installation's functional performance.

4.4.4 Periodic framework programme

The Operator shall establish a periodic framework programme for condition monitoring.

The inspection results and condition evaluation of these shall be reported in the condition report. Characterization of damage significant to the structural integrity and functional performance shall provide user groups with opportunity to assess the condition of the loadbearing structures and initiate corrective measures, in order that an adequate level of safety can be maintained.

History outline of damage or defects revealed, repairs and major modifications carried out in the operation phase should be included in a condition resumé. The mentioned outline should together with main results from structural studies, evaluations and assessments completed in this period be included in the condition summary which should be subject to continuous updating.

5 PROGRAMME FOR CONDITION MONITORING

5.1 Condition Monitoring Philosophy

The detailed condition monitoring programme of loadbearing structure depends on the design and maintenance philosophy, the current condition, the capability of the inspection methods available and the intended use of the structure. The focus should be put on the identified safety critical components, in addition to improving the accuracy and reliability of prediction of structural performance and in-service inspection methods.

Condition monitoring of the loadbearing structures includes the following major activities:

- Establishing a condition monitoring system comprising strategy, acceptance criteria, in-service inspection philosophy, evaluation and assessment methodology and a report routine. Necessary tools and software should also be defined in the system.
- Development of a long term condition monitoring programme (periodic framework programme) which is subject to continuous updating and revision.
- To carry out detailed inspection planning on a regular basis, e.g. annually.
- To execute the inspection work packages in accordance to the requirements specified.
- To record, evaluate and report inspection results.
- To monitor environmental conditions and the structural behaviour such as dynamic motions, foundation behaviour, erosion, strain of key components, etc. if the value or characteristics are highly uncertain. See also NORSOK N-002 "Collection of metocean data".
- Initiation of fitness for purpose assessments if initiators are revealed during routine evaluation of the inspection results.
- Consideration and conception of prevention and mitigation measures.
- Development of emergency preparedness systems including procedures for mobilisation of duty engineers, evacuation plan, system for unscheduled inspection on special occasions, post event assessment, production re-start after the events.

It should be noticed that operational aspects, such as inspection vessel management, use of ROVs, etc., are as important as the structural aspects with respect to life cycle cost and operational safety.

5.2 Requirements to a programme for condition monitoring

A programme for condition monitoring shall comply with the regulation requirements relating to planning of this type of activity. Structural design, technical solutions and areas requiring particular attention, for example accepted deviations from the presumptions described in and dealt with in the DFI resumé and the condition summary or the structural components significant to structural integrity and functional performance, should be focused when requirement specifications for condition monitoring are prepared.

Loadbearing structures on new installations shall be reviewed in order to get a picture of possible damage, defects deterioration and deviations revealed during the design and construction phases. This review should be carried out in the light of the design criteria of the installation. Knowledge of any damage and defects may enable the Operator to initiate necessary measures in time, and assess the need for monitoring, repairs or operational limitations for the installation.

When operational limitations are introduced as a part of the mitigation measures resulting from fitness for purpose assessment, the limitations may be included considering an overall safety level of the installation in question.

For floating structures a stability monitoring system shall be installed onboard.

5.3 Intervals for condition monitoring

5.3.1 Periodic framework programme

The first of the framework programmes should have an extent which as far as possible provides a description of the overall condition of the loadbearing structures. This framework programme shall be evaluated in relation to stipulated acceptance criteria for operation and deviations which is described and dealt with in the DFI resumé.

The first of the framework programmes should also be planned in connection with the condition monitoring which is to be performed after the installation is positioned, or in connection with putting the installation into operation.

Practice from the Norwegian petroleum activities indicates that the first framework programme should be completed within 3-5 years, depending on for example platform exposure, structural redundancy and extent of inspection during DFI phases. Based on information gained in the first period of operation and knowledge about the application of new analysis techniques and methods within condition monitoring and maintenance, the interval may be altered. A change in the duration of the framework programme should be based on maintaining an adequate level of safety and proper documentation of this.

The Operator should give emphasis to systematization of previously acquired data in subsequent planning and implementation of condition monitoring.

The framework programme and any changes on these shall be reported according to the regulations.

5.3.2 Initial condition survey

During the first year of operation of the installation, an initial condition survey should be carried out in order to enable an overall assessment of the ability of the loadbearing structures to meet the redefined acceptance criteria. The condition survey will be able to disclose damage or defects if any at an early stage such that corrective measures can be initiated as needed.

This activity may be included as part of the first periodic framework programme.

5.3.3 Periodic condition monitoring

Condition monitoring of the loadbearing structures shall be carried out regularly. Condition monitoring is assumed to be carried out according to the prepared periodic framework programme.

Requirements on condition evaluation will be specified as a part of condition assessment in subclause 6.5 which covers both routine evaluation of in-service inspection results and fitness for purpose assessment.

5.4 Unscheduled inspection on special occasions

Inspection should be conducted after extreme/accidental events or as a result of operational changes. The unscheduled inspection may also be conducted to monitor repair or other remedial programs. Any further actions to maintain an adequate level of structural integrity should then be based on results of the inspection and the other information available.

An unscheduled inspection may, subject to evaluation, be advanced or delayed to coincide with a scheduled inspection program.

5.5 Updating of programme for condition monitoring

The framework programme should be subject to review within the period of time for which it is applicable.

If the results from condition monitoring indicate deviations of significance to the structural integrity of loadbearing structure, the intervals for condition monitoring as well as the condition monitoring philosophy should be reconsidered and the framework programme should then be updated accordingly.

6 IMPLEMENTATION OF CONDITION MONITORING

6.1 Safety for inspection personnel

Safety for personnel engaged in inspection and maintenance activities should be considered in the design phase.

Diving operations should be avoided where possible.

It is the Operator's responsibility to ensure that:

- inspectors have received the necessary training and skills with respect to safety in inspection work