



NORSOK Standard

Z-008:2017

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Risk based maintenance and consequence classification

Standard Online AS

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Foreword

NORSOK Z-008:2017 was adopted as NORSOK Standard in December 2017.

NORSOK Z-008:2017 supersedes NORSOK Z-008:2011.

NORSOK is an acronym for the competitive position of the Norwegian continental shelf and comprise petroleum industry standards in Norway. The collaboration initiative in 1993 between the authorities and the petroleum industry initiated the development of NORSOK standards.

Reducing the project execution time and developing and operating cost for petroleum installations on the Norwegian shelf was the target.

The intention for the Petroleum industry is to develop and use standards providing good technical and cost effective solutions to ensure that the petroleum resources are exploited and managed in the best possible way by the industry and the authorities. The industry will actively contribute to the development and use of international standards in the global market.

The NORSOK standards shall:

- bridge the gap based on experiences from the Norwegian continental shelf where the international standards are unsatisfactorily;
- replace oil company specifications where possible;
- be available as references for the authorities' regulations;
- be cost effective; and
- promote the Norwegian sector as an attractive area for investments and activities.

Developing new NORSOK standards and regular maintenance of existing standards shall contribute to maintain the competitiveness both nationally and internationally for the Norwegian petroleum industry.

The NORSOK standards are developed by experts from the Norwegian petroleum industry and approved according to the consensus principles as laid down by the guidelines given in NORSOK A-001 N:2016 directive.

The NORSOK standards are owned by the Norwegian Oil and Gas Association, the Federation of Norwegian Industries and the Norwegian Shipowners' Association. They are managed and published by Standards Norway.

This NORSOK directive has been developed by Standards Norway in cooperation with the parties in the petroleum industry.

All sections are normative. All Annexes are informative.

The following has been changed since last edition (revision 3, June 2011):

- Changed scope to include all types of equipment in all types of installations
- Updated references and terminology. ISO14224:2016 is used as the basis for maintenance terminology
- Added section regarding input to consequence classification and maintenance engineering
- Description of maintenance engineering of technical barrier elements
- Better general description of work process for establish preventive maintenance programme
- Review of standard to improve consistency of standard (shall, should and can)

Introduction

The purpose of this NORSOK standard is to provide requirements and guidelines for

- establishment of technical hierarchy,
- consequence classification of equipment,
- how to use consequence classification in maintenance management,
- maintenance management of technical barrier elements
- how to use risk and reliability analysis to establish and update PM programmes,
- how to aid decisions related to maintenance using the underlying risk analysis,
- spare part evaluations.

This NORSOK standard is applicable for different purposes and phases such as:

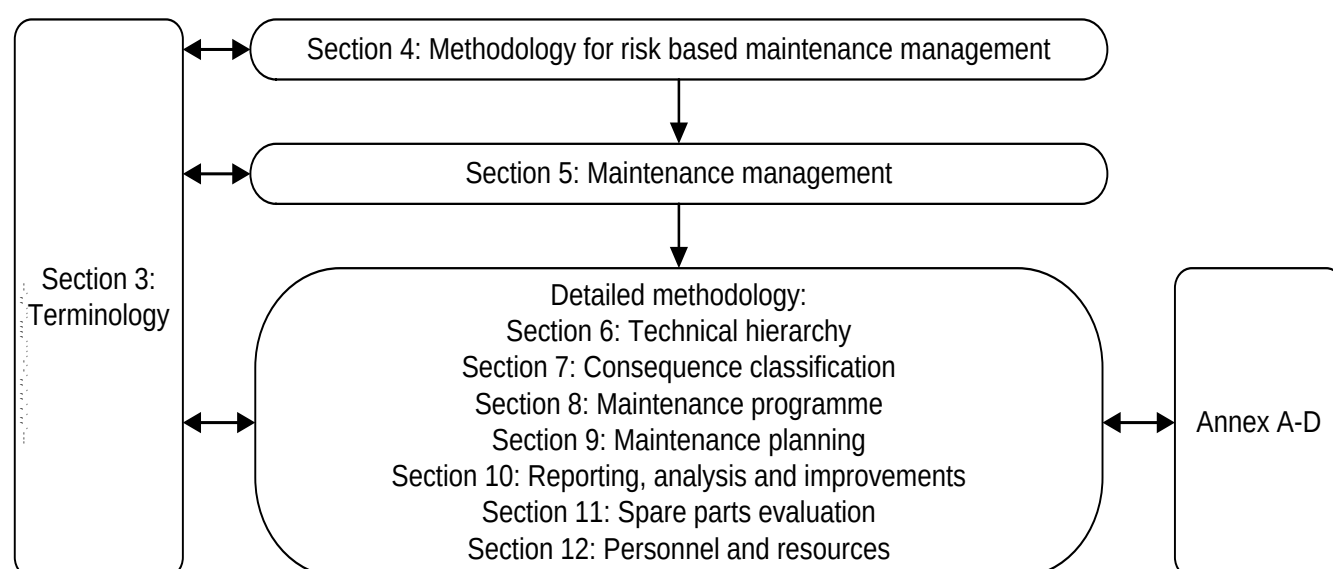
- **design phase:** establish initial maintenance programme as an input to manning requirements and system configuration. Selection of capital spare parts;
- **preparation for operation:** development of initial maintenance programmes for implementation into maintenance management systems and selection of spare parts;
- **operational phase:** updating and optimisation of existing maintenance programmes. Guidance for prioritising work orders. Lifetime extension.

As a basis for preparation and optimisation of maintenance programmes for new and in service facilities all risk elements shall be taken into account, i.e. risks related to

- personnel,
- environment,
- production loss,
- direct and indirect cost including reputation.

This NORSOK standard is meant to define level of how this shall be done and deviations shall only provide better solutions with regards to maintenance management. This NORSOK standard should also be seen in conjunction with ISO 20815.

The standard describes the key work processes with explanation and requirements to each of them, and is organized in the following way:



Risk based maintenance and consequence classification

1 Scope

This NORSOK standard is applicable for preparation and optimisation of maintenance activities for all plant systems and items.

The consequence classification and the maintenance task selection process can be applied to all types of items, and, in principle, all types of failure modes and failure mechanisms are covered by this NORSOK standard. However, for some types of items, other specific analysis should be performed to identify failure characteristics, failure frequencies and mitigating tasks. This include, among others, load bearing structures, static pressure equipment, risers and pipelines.

This standard is developed with the oil and gas industry in mind, but the principles within can be applied to any industry, including manufacturing or processing plants, ships/maritime and energy plants/installations.

This NORSOK standard covers

- definition of relevant nomenclature,
- brief description of main work flow related to maintenance and which elements this typically involves,
- definition of risk model and failure consequence classes,
- guidelines for consequence classification, including
 - functional breakdown of plants and plant systems in MFs and sub functions,
 - identification of MF and sub function redundancy,
 - assessment of the consequences of loss of MFs and sub functions,
 - assignment of equipment to sub functions and associated consequence classes,
- description of how to establish an initial maintenance programme, and how to update an existing programme,
- description on how to use the classification in combination with probability for decision making related to prioritising work orders and handling spare parts.

2 Normative references

The following standards include provisions and guidelines which, through reference in this text, constitute provisions and guidelines of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. For dated references, only the edition cited applies. Other recognized standards may be used provided it can be shown that they meet the requirements of the referenced standards.

IEC 60300-3-11,	<i>Dependability Management Part 3-11: Application guide – Reliability centred maintenance</i>
IEC 60812,	<i>Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA)</i>
IEC 61508,	<i>Functional safety for electrical/electronic/programmable electronic safety-related systems</i>
IEC 61511,	<i>Functional Safety – Safety instrumented systems for the process industry sector</i>
ISO 17776,	<i>Petroleum and natural gas industries - Offshore production installations - Major accident hazard management during the design of new installations</i>
ISO 20815,	<i>Petroleum, petrochemical and natural gas industries – Production assurance and reliability management</i>
ISO 13702,	<i>Petroleum and natural gas industries – Control and mitigation of fires and explosions on offshore production installations – Requirements and guidelines</i>
ISO 14224,	<i>Petroleum, petrochemical and natural gas industries – Collection and exchange of reliability and maintenance data for equipment, Edition 3, Sept. 2016</i>
NOG 070,	<i>Guidelines for the Application of IEC 61508 and IEC 61511 in the petroleum activities on the continental shelf</i>
NORSOK S-001,	<i>Technical safety</i>
NORSOK Z-013,	<i>Risk and emergency preparedness analysis</i>

For informative references, see Bibliography.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

active repair time

effective time to achieve repair of an item

Note 1 to entry: ISO 14224:2016 distinguishes between the terms mean active repair time (MART), mean time to repair (MTTR), mean time to restoration (MTTRes), and mean overall repairing time (MRT). See ISO 14224:2016 for further details.

Note 2 to entry: The mean active repair time (MART) is defined as “expected active repair time” in ISO/TR 12489:2013, 3.1.34. See also ISO/TR 12489:2013, Figures 5 and 6.

[SOURCE: ISO 14224:2016, 3.2]

3.1.2

availability

ability to be in a state to perform as required

Note 1 to entry: See ISO 14224:2016, Annex C for a more detailed description and interpretation of availability.

Note 2 to entry: Further terms are given in ISO/TR 12489:2013.

[SOURCE: ISO 14224:2016, 3.3]

3.1.3

barrier

functional grouping of safeguards or controls selected to prevent a major accident or limit the consequences

Note 1 to entry: Barriers can be subdivided into technical, operational and organisational barrier elements.

Note 2 to entry: This document focuses on technical barrier elements.

[SOURCE: ISO 17776:2016, 3.1.1]

3.1.4

can

expression in the content of a document conveying expected or conceivable material, physical or causal outcome.

[SOURCE: NORSOK A-001:2016, A5]

3.1.5

condition-based maintenance

preventive maintenance based on the assessment of physical condition

Note 1 to entry: The condition assessment can be by operator observation, conducted according to a schedule, or by condition monitoring of system parameters.

[SOURCE: ISO 14224:2016, 3.7]

3.1.6

condition monitoring

obtaining information about physical state or operational parameters

Note 1 to entry: Condition monitoring is used to determine when preventive maintenance may be required.

Note 2 to entry: Condition monitoring may be conducted automatically during operation or at planned intervals.

[SOURCE: IEC 60050-192:2015, 192-06-28]

3.1.7

consequence

outcome from an event

Note 1 to entry: There may be one or more consequences from an event. Consequences may range from positive to negative. However, consequences are always negative for safety aspects. Consequences may be expressed qualitatively or quantitatively.

Note 2 to entry: Annex C.2 and ISO 14224:2016, Annex C.1.10 give examples of consequence classification.

Note 3 to entry: See also definition of Failure Impact in 3.1.17.

3.1.8

consequence classification

qualitative analysis of events and failures and assignment of the consequences of these.

Note 1 to entry: See definitions in 3.1.9, 3.1.10 and 3.1.11.

3.1.9

consequence HSE

health, safety and/or environmental consequence of an event

3.1.10

consequence production

effect with regard to production of a functional failure where effects of mitigation (e.g. spare parts, manning, tools) and compensation measures are not considered (= unmitigated consequence)

3.1.11

consequence other

other consequences as a result of a functional failure other than HSE or production consequence

Note 1 to entry: May also include monetary losses and loss of reputation.

3.1.12

corrective maintenance

maintenance carried out after fault detection to affect restoration

Note 1 to entry: See also ISO/TR 12489:2013, Figures 5 and 6, which illustrate terms used for quantifying corrective maintenance.

[SOURCE: ISO 14224:2016, 3.8]

3.1.13

critical failure

failure of an equipment unit that causes an immediate cessation of the ability to perform a required function

Note 1 to entry: Includes failures requiring immediate action towards cessation of performing the function, even though actual operation can continue for a short period of time. A critical failure results in an unscheduled repair.

[SOURCE: ISO 14224:2016, 3.9]

3.1.14

degraded failure

failure that does not cease the fundamental function(s), but compromises one or several functions

Note 1 to entry: The failure can be gradual, partial or both. The function can be compromised by any combination of reduced, increased or erratic outputs. An immediate repair can normally be delayed but, in time, such failures can develop into a critical failure if corrective actions are not taken.

[SOURCE: ISO 14224:2016, 3.11]

3.1.15

equipment class

class of similar type of equipment units (e.g. all pumps)

Note 1 to entry: Annex A in ISO 14224:2016 gives equipment classes and also contains equipment-specific data for the equipment class.

[SOURCE: ISO 14224:2016, 3.18]

3.1.16

failure

<of an item> loss of ability to perform as required

Note 1 to entry: A failure of an item is an event that results in a fault of that item: see fault (3.1.17).

Note 2 to entry: A failure of an item is an event, as distinct from a fault of an item, which is a state [ISO/TR 12489:2013].

[SOURCE: ISO 14224:2016, 3.23]

3.1.17

failure cause

set of circumstances that leads to failure

Note 1 to entry: A failure cause can originate during specification, design, manufacture, installation, operation for maintenance of an item.

Note 2 to entry: See also ISO 14224:2016, B.2.3 and Table B.3 which define failure causes for all equipment classes.

[SOURCE: ISO 14224:2016, 3.24]

3.1.18

failure frequency

unconditional failure intensity; conditional probability per unit of time that the item fails between t and $t + dt$, provided that it was working at time 0

Note 1 to entry: Another term used for failure frequency is "rate of occurrence".

Note 2 to entry: See ISO 14224:2016, C.3 with respect to failure rate and failure frequency estimations.

Note 3 to entry: Note the difference between failure rate and failure frequency. Failure rate is defined in ISO 14224:2016, 3.32.

[SOURCE: ISO 14224:2016, 3.27]

3.1.19

failure impact

effect of a failure on an equipment's function(s) or on the plant

Note 1 to entry: On the equipment level, failure impact can be classified in three classes (critical, degraded and incipient); see definitions of "critical failure", "degraded failure" and "incipient failure" in ISO 14224:2016, 3.9, 3.11, and 3.40.

[SOURCE: ISO 14224:2016, 3.28]

3.1.20

failure mechanism

process that leads to failure

Note 1 to entry: The process can be physical, chemical, logical, or a combination thereof.

Note 2 to entry: See also ISO 14224:2016, B.2.2 and Table B.2, which define failure causes for all equipment classes.

[SOURCE: ISO 14224:2016, 3.29]

3.1.21

failure mode

manner in which failure occurs

Note 1 to entry: See also the tables in ISO 14224:2016, B.2.6 on the relevant failure modes which define failure modes to be used for each equipment class.

[SOURCE: ISO 14224:2016, 3.30]

3.1.22

failure rate

conditional probability per unit of time that the item fails between t and $t + dt$, provided that it has been working over $[0, t]$

Note 1 to entry: See also definition of failure rate in ISO/TR 12489:2013, 3.1.18.

Note 2 to entry: See ISO 14224:2016, C.3 with respect to failure rate and failure frequency estimations

Note 3 to entry: Note the difference between failure rate and failure frequency. Failure frequency is defined in ISO 14224:2016, 3.27.

[SOURCE: ISO 14224:2016, 3.32]

3.1.23

fault

inability to perform as required, due to an internal state

Note 1 to entry: A fault of an item results from a failure, either of the item itself, or from a deficiency in an earlier stage of the life cycle, such as specification, design, manufacture or maintenance. See also latent fault (ISO 14224:2016, 3.44).

Note 2 to entry: A fault is often a result of a failure of the item itself but the state can exist without a failure (see ISO 20815:2008, 3.1.14).

Note 3 to entry: See also ISO/TR 12489:2013, 3.2.2.

[SOURCE: ISO 14224:2016, 3.33]

3.1.24

generic maintenance concept

GMC

set of maintenance actions, strategies and maintenance details, which demonstrates a cost-efficient maintenance method for a defined generic group of equipment functioning under similar frame and operating conditions

3.1.25

hazard

potential source of harm

Note 1 to entry: In the context of this NORSOK standard, the potential harm may relate to human injury, damage to the environment, damage to property, or a combination of these.

[SOURCE: ISO 17776:2016, 3.1.9]

3.1.26

hidden failure

failure that is not immediately evident to operations and maintenance personnel

Note 1 to entry: Equipment failures that occurred at an earlier point of time, but were first observed at demand, fall into this category. Such failures are first revealed when the relevant functionality is tested (activated).

Note 2 to entry: See definition with notes to entry in ISO/TR 12489:2013, 3.2.11.

Note 3 to entry: See also latent fault (ISO 14224:2016; 3.44).

[SOURCE: ISO 14224:2016, 3.35]

3.1.27

incipient failure

imperfection in the state or condition of an item so that a degraded or critical failure might (or might not) eventually be the expected result if corrective actions are not taken

Note 1 to entry: The recording of incipient failure requires some criteria for when a fault of this nature requires registration as opposed to a state/condition where no corrective actions are required.

[SOURCE: ISO 14224:2016, 3.40]

3.1.28

inspection

activity carried out periodically and used to assess the progress of damage in a component

Note 1 to entry: Inspection can be by means of technical instruments (e.g. NDT) or as visual examination.

Note 2 to entry: This document uses the common term "inspection" in the oil and gas industry, which relates inspection and inspection management to the activity of checking the conformity of the equipment by NDT instruments or visual examination at regular intervals.

[SOURCE: DNVGL-RP-G101:2010]

3.1.29

item

subject being considered

Note 1 to entry: The item can be an individual part, component, device, functional unit, equipment, subsystem, or system.

[SOURCE: ISO 14224:2016, 3.43]

3.1.30

main function

MF

principal tasks in a system being considered

Note 1 to entry: Annex A gives an overview of typical MFs for an oil and gas production plant.

3.1.31

maintainability

<of an item> ability to be retained in, or restored to a state to perform as required, under given conditions of use and maintenance

Note 1 to entry: Given conditions would include aspects that affect maintainability, such as: location for maintenance, accessibility, maintenance procedures and maintenance resources.

Note 2 to entry: See also ISO 14224:2016, Annex C for a more detailed definition and interpretation of maintainability.

[SOURCE: ISO 14224:2016, 3.47]

3.1.32

maintainable item

item that constitutes a part, or an assembly of parts that is normally the lowest level in the equipment hierarchy during maintenance

[SOURCE: ISO 14224:2016, 3.48]

3.1.33

maintenance

combination of all technical and management actions intended to retain an item in, or restore it to, a state in which it can perform as required

Note 1 to entry: ISO 14224:2016, Figure 6 shows the main maintenance categories in more detail. ISO 14224:2016, Table B.5 presents the main types of maintenance activities commonly performed.

[SOURCE: ISO 14224:2016, 3.49]

3.1.34

maintenance effectiveness

ratio between the maintenance actual result and performance target

Note 1 to entry: See examples of KPIs in Clause 10 and ISO 20815:2008, Annex E that can be used for measure of maintenance effectiveness.

3.1.35

maintenance management

all activities of the management that determine the maintenance objectives, strategies, and the responsibilities and implement them by means such as maintenance planning, maintenance control and supervision, improvements of methods in the organisation including economical aspects

[SOURCE: EN 13306:2010, 2.2]

3.1.36**maintenance strategy**

management method used in order to achieve the maintenance objectives

[SOURCE: EN 13306:2010, 2.4]

3.1.37**may**

expression in the content of a document conveying consent or liberty (or opportunity) to do something

Note 1 to entry: Permissions are expressed using the verbal forms specified in ISO/IEC Directives Part 2 clause 7.4 Table 5.

[SOURCE: NORSOK A-001:2016, A.5]

3.1.38**modification**

combination of all technical and administrative actions intended to change an item

Note 1 to entry: Modification is not normally a part of maintenance, but is frequently performed by maintenance personnel.

Note 2 to entry: Care is needed to distinguish between maintenance due to failures and maintenance due to equipment modification.

[SOURCE: ISO 14224:2016, 3.67]

3.1.39**performance standard****PS**

measurable statement, expressed in qualitative or quantitative terms, of the performance required of a system, item of equipment, person or procedure, and that is relied upon as a basis for managing a hazard

Note 1 to entry: Hardware performance standards address the functionality, reliability, survivability and interdependency of barriers under emergency conditions.

[SOURCE: ISO 17776:2016, 3.1.17]

3.1.40**predictive maintenance**

maintenance based on the prediction of the future condition of an item estimated or calculated from a defined set of historic data and known future operational parameters

[SOURCE: ISO 14224:2016, 3.77]

3.1.41**preventive maintenance****PM**

maintenance carried out to mitigate degradation and reduce the probability of failure

Note 1 to entry: Preventive maintenance contains condition-based maintenance and predetermined maintenance, see ISO 14224:2016, Figure 6.

[SOURCE: ISO 14224:2016, 3.78]

3.1.42

production assurance

activities implemented to achieve and maintain a performance that is at its optimum in terms of the overall economy and at the same time consistent with applicable framework conditions

[SOURCE: ISO 20815:2008, 3.1.37]

3.1.43

redundancy

existence of more than one means for performing a required function of an item

Note 1 to entry: See ISO 14224:2016, C.1.2 for further details, where passive (cold), active (hot) standby and mixed redundancy are described.

Note 2 to entry: Redundancy in IEC 61508:2010 is called “fault tolerance”.

[SOURCE: ISO 14224:2016, 3.80]

3.1.44

reliability

ability of an item to perform a required function under given conditions for a given time interval

[SOURCE: ISO 14224:2016, 3.81]

3.1.45

reliability centred maintenance

RCM

Systematic method for determining the respective maintenance actions and associated frequencies, based on the probability and consequence of failure

[SOURCE: IEC 60050-192:2015, 192-06-08]

3.1.46

required function

function or combination of functions of an item that is considered necessary to provide a given service

[SOURCE: ISO 14224:2016, 3.1.83]

3.1.47

risk

combination of the probability of an event and the consequence of the event

Note 1 to entry: See further important information regarding definition of risk in ISO 20815.

[SOURCE: ISO 20815:2008, 3.1.44]

3.1.48

risk based inspection

RBI

a decision making technique for inspection planning based on risk, compromising the probability of failure and the consequence of failure

Note 1 to entry: These risks are managed primarily through equipment inspection.

[SOURCE: DNV-RP-G101:2010]

3.1.49

safety system

system which is used to implement one or more safety functions

Note 1 to entry: Safety function is in ISO/TR 12489:2013, 3.1.6 defined as “function which is intended to achieve or maintain a safe state, in respect of a specific hazardous event”.

Note 2 to entry: Systems with safety functions are defined in ISO/TR 12489:2013, Annex A. These systems are also cross-related in ISO 14224:2016, Table A.3.

[SOURCE: ISO 14224:2016, 3.86]

3.1.50

shall

expression in the content of a document conveying objectively verifiable criteria to be fulfilled and from which no deviation is permitted if compliance with the document is to be claimed

Note 1 to entry: Requirements are expressed using the verbal forms specified in ISO/IEC Directives, Part 2 clause 7.2 Table 3.

[SOURCE: NORSOK A-001:2016, A.5]

3.1.51

should

expression in the content of a document conveying a suggested possible choice or course of action deemed to be particularly suitable without necessarily mentioning or excluding others

Note 1 to entry: Recommendations are expressed using the verbal forms specified in ISO/IEC Directives, Part 2 clause 7.3 Table 4.

Note 2 to entry: In the negative form, a recommendation is the expression that a suggested possible choice or course of action is not preferred but it is not prohibited.

[SOURCE: NORSOK A-001:2016, A.5]

3.1.52

sub function

grouping of items performing the same function within a main function

Note 1 to entry: See Annex B for a list of standardized sub functions.

3.1.53

tag/ tag number

unique code that identifies the equipment function and its physical location

[SOURCE: ISO 14224:2016, 3.91]

3.1.54

unsafe failure

failure of a safety system which tends to impede a given safety action

Note 1 to entry: When dealing with safety instrumented systems, unsafe" is synonymous with "dangerous".

Note 2 to entry: An unsafe failure of an item is not necessarily a critical failure of the item. See further information in Clause 8.3.

[SOURCE: ISO/TR 12489:2013, 3.2.3]

3.2 Abbreviated terms

API	American Petroleum Institute
BOM	bill of material
CE	Conformité Européenne
CM	corrective maintenance
CMMS	computerized maintenance management system
EN	European Standard
FMECA	failure mode, effect and criticality analysis
GMC	generic maintenance concept
HSE	health, safety and environment
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
KPI	key performance indicator
LCC	life cycle cost
LCP	life cycle profit
MF	main function
NDT	non destructive testing
NOG	Norwegian Oil and Gas Association
OEM	original equipment manufacturer
OREDA®	offshore and onshore reliability data
P&ID	process and instrumentation diagram
PM	preventive maintenance
PS	performance standard
PSA	Petroleum Safety Authority
PU	parallel unit
QRA	quantitative risk analysis
RBI	risk based inspection
RCM	reliability centred maintenance
SIL	safety integrity level

4 Methodology for risk based maintenance management

4.1 General

Risk assessment shall be used as the guiding principle for maintenance decisions. This document describes how to apply this in an efficient manner. The key elements of this methodology are as follows:

- a) consequence classification of functional failure;
- b) a risk based maintenance task selection process. Identification of relevant failure modes and estimation of failure probability should primarily be based on operational experience of the actual equipment. Alternatively generic failure data from similar operations may be used with sufficient reliability data qualification in accordance with ISO 20815, Annex E.2;
- c) use of Generic Maintenance Concepts (GMCs) in combination with classical RCM methods. The GMCs are developed by RCM analysis including plant experience. The GMCs will implicitly express the probability of failure via the maintenance tasks and the maintenance interval assigned. It is recommended that the GMCs are adjusted to the local conditions via a cost-benefit assessment and including other local conditions;
- d) in case no GMCs are applicable or the purpose of the study requires more in-depth evaluations, an FMECA/RCM/RBI analysis shall be carried out;
- e) the application of the consequence classification and additional risk factors for decision making related to corrective maintenance and handling of spare parts.

As important as the risk assessment, is having well defined work processes and company/management commitment. This document describes the main work flow and sets minimum requirements to each of the steps in this process. Further the process points out the importance of continuous improvement based on reporting and analysis of the plant condition.

4.2 Technical barrier elements

Safety and/or environmental barrier elements are defined as part of a major accident hazard management process, ref. ISO 17776 and NORSOK Z-013. The major accident scenarios are defined and barrier functions and barrier systems that prevent or mitigate the hazard are identified. Performance requirements are established as part of this analysis and the overall performance is documented in the form of Performance Standards (PS) or equivalent. The PS' will set requirements with respect to availability, capacity and performance of barrier functions. Reference is made to NORSOK S-001, ISO 13702, IEC 61508, IEC 61511, NOG 070, ISO/TR12489 and ISO 20815.

ISO 14224, F.4.2, lists the most common safety systems/components for an oil and gas installation with definition of critical/dangerous failure modes.

Technical barrier elements are the physical items that realize one or several of the barrier functions.

One of the most important tasks for the maintenance organisation is to maintain this performance during the lifecycle of the plant. Availability requirements shall be used to determine the programme for PM activities and the required contingency plans in the event of failure.

See Clause 7 for consequence classification of technical barrier elements.

See Subclause 8.4 for maintenance of technical barrier elements.

The technical availability of the barrier functions shall be controlled and documented at all times. The development of failure frequency and system unavailability shall be used as the basis for changing of test intervals and other mitigating actions to ensure compliance with functional requirements.

See Clause 10 for more information regarding reporting requirements.

4.3 Static process equipment

Static process equipment has a dual function, i.e. a function related to storing or transporting gas or liquids, and a containment function related to preventing external leakage of gas and liquids. The functional requirement to the storing or transporting of gas and liquids are covered by document, see Clause 7.

In order to establish an inspection programme for the containment function of the equipment, it is necessary to perform detailed evaluations similar to a FMECA and RCM process, usually named RBI. The process requires knowledge of

- failure mechanism which depends on material properties, internal fluid compositions and the external operational environment – determining the probability of failure,
- consequence of leakage with respect to personnel, environment damages and financial losses.

The combination of the above represents the risk of failure which shall be mitigated.

The consequence classification methodology could be applied for screening of static mechanical equipment with the purpose of excluding non-critical equipment for further analysis and prioritise other equipment for in-depth risk evaluations as the basis for preparation of inspection programmes.

The result of the RBI process is determination of

- location and extent of inspections and condition monitoring,
- inspection methods,
- inspection intervals.

There exist several standards for performing RBI analysis depending on type of object. Reference is made to DNVGL-RP-G101 for topside systems, DNVGL-RP-F206 for risers, DNVGL-RP-F116 for submarine pipeline systems and DNVGL-RP-0002 for subsea production systems. For refineries API RP 580 can be applied.

4.4 Risk decision criteria

Risk based decisions shall be done against defined criteria. The definition of the criteria should be done in accordance with overall company policy for HSE, production and cost. The criteria shall be properly defined and communicated to all personnel involved in risk decision, including operational personnel.

This document will not define any generic criteria, but describe an example of such criteria. See also NORSOK Z-013, ISO 17776 and ISO 14224. The level of detailing in any risk matrix used is company specific, and can typical vary from a coarse 3x3 matrix to a more detailed 5x10 matrix.

The following principles should apply:

- the consequence- and risk matrices used for maintenance purposes should as far as possible be aligned with the overall company risk matrices but can be customized for maintenance purposes to aid proper planning and prioritizing of maintenance activities, and should be the same for all operations for a company in order to aid common companywide optimization and devote resources accordingly, as well as having a common terminology for communicating risk;
- further, the same criteria should be used for all equipment and systems (also for equipment covered by other standards, such as load bearing structures, risers and pipelines). This is particularly important for topside maintenance and inspection planning which are handling basically the same hardware;
- the consequence of loss of functionality (both loss of MF and sub functions) shall take into account the standby redundancy (see 3.1.43) and reduce the impact accordingly.

Annex C gives example of criteria which can be used for classification, development of preventive work tasks and for prioritisation of work orders, as well as for optimisation of spare parts.