



BSI Standards Publication

Petroleum and natural gas industries — Specific requirements for offshore structures

Part 9: Structural integrity management

National foreword

This British Standard is the UK implementation of EN ISO 19901-9:2019. It is identical to ISO 19901-9:2019.

The UK participation in its preparation was entrusted to Technical Committee B/525/12, Design of offshore structures.

A list of organizations represented on this committee can be obtained on request to its secretary.

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requirements for offshore structures - Part 9: Structural
integrity management (ISO 19901-9:2019)**

Industries du pétrole et du gaz naturel - Exigences
spécifiques relatives aux structures en mer - Partie 9:
Gestion de l'intégrité structurelle (ISO 19901-9:2019)

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für Konstruktionen (ISO 19901-9:2019)

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European foreword

This document (EN ISO 19901-9:2019) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" the secretariat of which is held by NEN.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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A list of all parts in the ISO 19901 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Structural integrity management (SIM) is the implementation of engineering, inspection, maintenance, monitoring and remediation activities required to demonstrate the fitness-for-service of a structure for its intended application throughout its total service life and prevent/mitigate severe or catastrophic health, safety, environmental, or structural events. The SIM process provides a proactive approach to monitor, evaluate and assess structural condition and establish a procedure to validate the fitness-for-service of an offshore structure.

The purpose of SIM is to provide a process for demonstrating the integrity of the structure throughout its intended total service life. Approaches to dealing with SIM vary depending upon field life, the type of structure and the sophistication of regional infrastructure where the structure is located. In turn, these factors can influence the philosophical approach to the specification of SIM which can vary from one involving emphasis on the use of monitoring equipment to one with a preference for the extensive use of inspections. Additionally, design decisions on safety factors, design margins, corrosion protection, component redundancy and system reliabilities will influence the SIM strategy and program.

SIM process choices are made in the design (e.g. selection of materials, condition monitoring systems, new or proven technology, robustness of design, redundancy, and fabrication/installation methods) that will influence SIM activities during the operations phase. Implementation of a SIM process can benefit significantly from design decisions, such as providing access for inspection and maintenance.

A SIM process is used to develop an inspection scope, program and frequency that, when executed, provides information on the condition of the structure, which can be used to understand present and emerging risk from operating the topsides, and provide information for determining the ongoing strategy for mitigating that risk. A well-implemented SIM process will maintain the structure's fitness-for-service for the operational life of the platform and through the decommissioning process.

Initial SIM development begins early as part of the structure's new design or reuse, ideally during the structure's concept and select stages. Most of the initial SIM data, strategies and program philosophies will be generated during the design by the project team and ultimately handed over to the structure's operating team. Once commissioned, the effective operation of the structure is contingent on the provided SIM philosophy and design documentation from the project team. These deliverables (e.g. design documents, drawings, computer models) are most useful to the operating team when they are complete, up-to-date (i.e. reflect as commissioned installation), organized, in a usable format and readily accessible. To provide sustainable SIM, the project team and operating team work collaboratively during the project in defining the necessary SIM deliverables.

The platform operating team is responsible for validating that the design data are comprehensive and complete. In addition, the operating team is responsible for demonstrating that the SIM strategies conform to the operator's risk criteria, regional regulations and that the SIM strategies are workable based on location infrastructure and capabilities. National and regional regulations can require SIM documentation in a form suitable for verification or for review by a regulator.

ISO 19904-1^[5] is applicable to the integrity management (IM) of hull, moorings and marine systems of existing floating offshore structures. However, this document is applicable to the structural integrity management of the topsides structural components of floating facilities.

ISO 19905-1^[6] is applicable to the IM of the legs, primary hull structure, spudcans, jacking-systems and marine systems of existing mobile jack-up offshore structures and for setting the limit states. However, this document is applicable to the structural integrity management of permanently located jack-ups.

Petroleum and natural gas industries — Specific requirements for offshore structures —

Part 9: Structural integrity management

1 Scope

This document specifies principles for the structural integrity management (SIM) of offshore structures subjected to known or foreseeable types of actions.

This document specifies requirements and provides recommendations applicable to the following types of fixed steel offshore structures for the petroleum and natural gas industries:

- caissons, free-standing and braced;
- jackets;
- monotowers;
- towers.

This document is applicable to topsides, including but not limited to the main decks, deck legs, topsides modules, crane pedestals, helideck, drilling derrick, skid beams, flare booms, exhaust towers, radio tower, conductor support frames, and lifeboat davits. In addition, it is applicable to compliant bottom founded structures, steel gravity structures, jack-ups, other bottom founded structures and other structures related to offshore structures (e.g. underwater oil storage tanks, bridges and connecting structures), to the extent to which its requirements are relevant.

This document contains requirements for planning and engineering of the following tasks:

- a) integrity management data requirements;
- b) in-service inspection and integrity management of both new and existing structures;
- c) assessment of existing structures;
- d) evaluation of structures for reuse at different locations;
- e) evaluation of structures for their future removal.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19900, *Petroleum and natural gas industries — General requirements for offshore structures*

ISO 19901-1, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 1: Metocean design and operating considerations*

ISO 19901-2, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 2: Seismic design procedures and criteria*

ISO 19901-4, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 4: Geotechnical and foundation design considerations*

ISO 19901-5, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 5: Weight control during engineering and construction*

ISO 19902, *Petroleum and natural gas industries — Fixed steel offshore structures*

ISO 19906, *Petroleum and natural gas industries — Arctic offshore structures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19900, ISO 19901-1, ISO 19901-2, ISO 19901-4, ISO 19901-5, ISO 19902 and ISO 19906 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 **anomaly**

in-service survey measurement, which is outside the threshold acceptable from the design or most recent fitness-for-service assessment

3.2 **assessment**

detailed qualitative or quantitative determination of the structural component or system strength

3.3 **assurance**

process to confirm that *SIM* (3.21) is performed in conformity with the procedures set out in the *SIM* policy and written description

3.4 **collapse**

loss of the load-bearing capacity of the platform through failure of one or more structural components

3.5 **continual improvement**

ongoing implementation of findings of reviews to improve the *SIM* process

3.6 **defect**

imperfection, fault, or flaw in a structural component

3.7 **emergency response plan**

written document associated with an asset, which defines the actions intended to protect people, the environment, and property from adverse consequences associated with emergency situations

3.8 **inspection program**

scope of work for the offshore execution of the inspection activities to determine the condition of the structure

3.9 **inspection strategy**

systematic approach to the development of a plan for the in-service inspection of a structure

3.10**mitigation**

limitation of negative consequence or reduction in likelihood of a hazardous event or condition

3.11**non-conformance**

insufficient strength or inadequate performance of a structure or structural component relative to a limit state or *performance level* (3.13)

3.12**non-redundant**

platform for which its global capacity is reached when one of its primary structural elements reaches its maximum capacity

3.13**performance level**

required functionality of the structure during and after a hazardous event

3.14**performance standard**

statement of the performance required of a system, item of equipment, person or procedure, which is used as the basis for managing the hazard through the lifecycle of the platform

3.15**prior exposure**

historical exposure of a structure to significant metocean, seismic or ice events

3.16**redundancy**

availability of alternate load paths in a structure following the loss of connection of one or more structural components

3.17**residual strength**

maximum strength of a structure in a damaged condition

3.18**risk-based inspection****RBI**

inspection strategies developed from an evaluation of the risk associated with a structure with the intention of tailoring inspection scope and frequency to risk magnitude and location

3.19**structural analysis**

determination of the effects of actions on structures and their components

3.20**structural assessment**

interpretation of available information including available analysis results used to confirm or otherwise the integrity of the structure

3.21**structural integrity management****SIM**

systematic multi-step cyclic process intended to assure structural integrity and functionality of a structure throughout its total service life

[SOURCE: ISO 19900:2019, 3.51]

3.22

tolerable risk

level of risk deemed acceptable by society in order that some benefit or functionality can be obtained, but in the knowledge that the risk has been evaluated and is being managed

3.23

weight database

live document containing the present base and factored, dry and operating weight and CoG data for an installation's substructure and topside, broken down by module and by engineering discipline

4 Symbols

The following is a summary of the main symbols that are used throughout this document. Many other symbols are locally defined where they are used. Local use includes main symbols with one or more subscripts when a more specific use and associated definition of the symbol is intended.

A	deck area
C_C	metocean or seismic hazard curve correction factor
C_d	drag coefficient
C_m	moment reduction factor
C_r	seismic reserve capacity factor
CoV_R	resistance coefficient of variance
D	diameter
$D1$	existing fatigue damage
$D2$	future fatigue damage
E	environmental action
E_{RP}	metocean action with return period of RP
E_{100}	metocean 100-yr action
F	cumulative probability of fatalities
F_{int}	intolerable number of fatalities
$F-N$	frequency-number
G	permanent action
H_s	significant wave height
L	span or length
N	number of fatalities
P_f	probability of failure
$p-y$	lateral soil resistance versus local pile displacement
Q	variable action

Q - z	pile end bearing resistance versus pile tip displacement
r	resolving vector
RP	return period
S	internal force
t - z	axial soil-pile shear transfer versus local axial pile displacement"
T	thickness of a structural element or plate
T_{dom}	dominant natural period
U	current speed
WiDA	wave-in-deck action
WiJA	wave-in-jacket action
Γ	participation factor
Φ	modal displacement
γ	partial safety factor
Δ	deflection with subscripts for various component effects
φ	dynamic coefficient

5 Abbreviated terms

ACFM	alternating current field measurement
ADS	atmospheric diving suit
ALE	abnormal level earthquake
ALS	accidental or abnormal limit state
CoG	centre of gravity
CoV	coefficient of variance
CP	cathodic protection
CPT	cone penetration test
CS	critical structure
CVI	close visual inspection
DLM	design level method
ELE	extreme level earthquake
FMD	flooded member detection
GVI	general visual inspection

HSE	health, safety and environmental
LQ	living quarters
MOC	management of change
MPI	magnetic particle inspection
NDE	non-destructive examination
ROV	remotely operated vehicle
SMR	strengthening, modification and/or repair
SRA	structural reliability analysis
TR	temporary refuge
ULS	ultimate limit state
UR	utilization ratio
USM	ultimate strength method
WiD	wave in deck

6 SIM fundamentals

6.1 General

SIM is used to manage the effects of deterioration, damage, changes in actions and accidental overloading. In addition, SIM is used to establish the framework for inspection planning, maintenance, and repair of a structure or group of structures.

6.2 Limit states and performance levels

In the design phase, exposure levels and limit states are specified for the structure and/or structural components.

The most severe consequences are categorized through defining exposure levels appropriate for the structure (ISO 19900). ISO 19900 further details the process for specifying appropriate limit states and for verifying that such limits are not exceeded. For fixed steel structures, ISO 19902 details the design/assessment criteria for the highest exposure level, L1, which covers manned and high environmental pollution exposed structures. These criteria are supplemented in ISO 19901-3^[2] for topsides and 19906 for structures in arctic and cold climate regions.

Other limit states can be specified by stakeholders, such as those on L1 and L2 structures that cover potential financial and reputational events.

Where several limit states are associated with the same hazardous event, these can be termed performance levels.

6.3 Fitness-for-service assessment

Fitness-for-service assessment leads to an approximate likelihood of exceeding the limit state for a given hazardous event, which combined with a consequence model gives an estimate of risk. This allows the operator to specify risk-based inspection plans.

Motives for performing fitness-for-service assessments should be established prior to selecting the assessment method. Motives can be driven by desire to optimize an inspection program and/or the desire to understand the cost-benefit in determining the effectiveness of a mitigation strategy.

Fitness-for-service evaluation is detailed in [Clause 9](#) while the assessment procedure is detailed in [Clause 12](#).

6.4 Management framework

The operator shall establish and maintain a management framework that provides evidence to the corporate and regulatory stakeholders that the operator has a commitment to a sustainable lifecycle approach to demonstrate the structure is fit-for-service.

The management framework refers to the integrated systems, work processes and documentation, which are used together with the SIM process to deliver structural integrity.

The SIM framework should align with the HSE and business objectives and should have the following interrelated elements:

- policy, which sets out the intention and direction of the operator with respect to SIM;
- written description, which documents the processes and procedures adopted by the operator for the management of the structural integrity;
- organization and personnel, which provides the reporting lines, accountabilities, roles and responsibilities, and competencies required for the personnel;
- SIM process, which is used for demonstrating fit-for-service assets based on asset information/data asset from inception to decommissioning;
- procedures, which are followed for the implementation of the required activities;
- MOC, which is used to identify and monitor changes;
- validation, which is used to measure and verify the implementation against a set of defined metrics;
- continual improvement, which reviews the process periodically and implements required changes.

Core of the management framework is the SIM process (see [Clause 7](#)) as illustrated in [Figure 1](#). The other elements mainly support this core process.

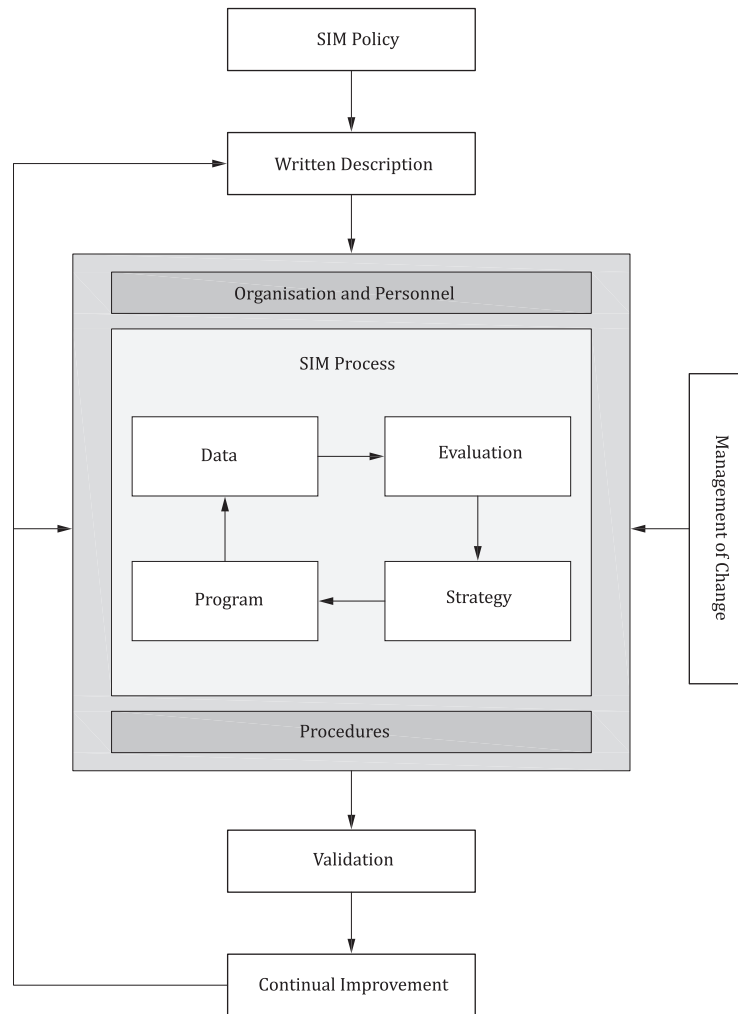


Figure 1 — Management framework

6.5 Design

SIM should be established during the project phase, and should include a systematic and iterative review of risks. Links between design, operations, inspection and maintenance should be addressed during design.

The operator should identify the hazardous events to the structure and structural components and their associated risks, and subsequently develop strategies to manage these risks. This should include identifying the inspection, maintenance and monitoring requirements and possibly adjusting the structural design to accommodate the SIM requirements (see [Clause 10](#)).

Before the start of operations of a new or newly acquired facility, the SIM data generated during the project or available from the previous operator should be made available to the operations team responsible for structural integrity. Handover to operations should include:

- transfer of design, fabrication and installation data;
- identification of critical structure for the substructure and topsides;
- initial risk assessment;
- initial long-term plans for inspection, maintenance and monitoring.

Design should incorporate SIM operational learnings and experience into new designs or brownfield modifications, including:

- site-specific criteria;
- damage to existing structures and the causes;
- vessel activity in the region;
- local regulatory requirements;
- decommissioning requirements and regulations;
- general operational experience relating to structural integrity, including appurtenances.

6.6 Topsides

SIM shall include topsides structures with focus on structural components that provide safety to personnel in the event of an incident or accident.

Topsides SIM shall address the interfaces with other discipline-specific integrity programs and the SIM of third-party packages included on the topsides.

SIM of a topsides structure shall be consistent with the SIM process principles used for the supporting structure.

6.7 Continued service

As the structural components age and the structure approaches the end of its service life, the operator shall demonstrate that the structure is fit-for-service during the extended service life.

The operator shall demonstrate that risks are at tolerable levels and the structure can be maintained in a fit-for-service condition through the planned extended total service life.

NOTE To extend the design service life, the assessment initiator occurs at the time the operator proposes to extend the operational service beyond the presently approved design service life. The initiator is not triggered by the age of the structure, but rather when the decision is made to extend the operational service life. This can occur at any time during the structure's service life.

6.8 Structural integrity interfaces

Offshore structures have inspection interfaces, which should be understood and managed within the SIM process. Structural integrity interfaces include:

- topsides / support structure connection;
- boundary between above and below water inspection;
- activities performed by other disciplines (e.g. caisson internal inspection) or equipment vendors.

Inspection interfaces between topsides and support structures for SIM can vary by platform type.

7 SIM process

The SIM process involves the periodic evaluation of data to define mitigation strategies and programs.

The SIM process shall consist of four primary elements, as illustrated in [Figure 2](#):

- a) data;
- b) evaluation;

- c) strategy;
- d) program.

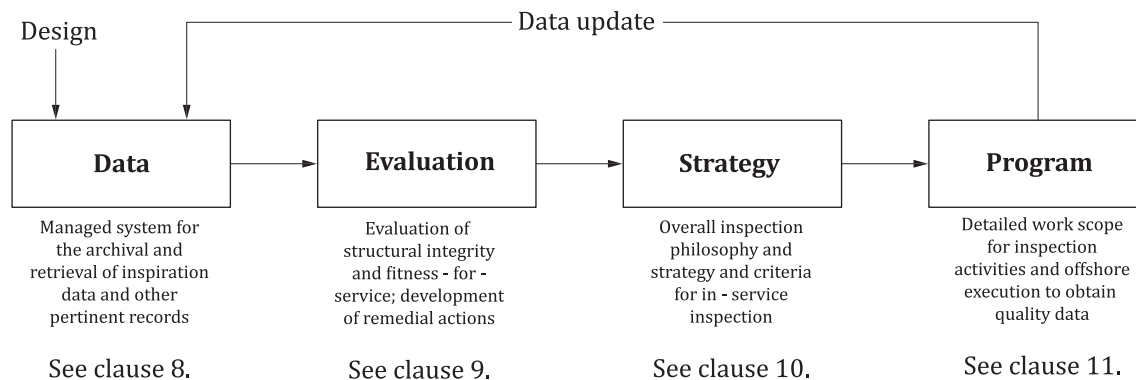


Figure 2 — SIM process

8 SIM data

8.1 General

An in-service data management system containing SIM data shall be established and maintained for the total service life of the structure.

Data shall include information from the original design of the structure, fabrication and installation data, inspection findings, effects of damage and deterioration, structural analyses, overloading, and changes in loading and/or use.

Data should be collated into a data management system at the completion of the design, fabrication and installation phases of a project.

Data for SIM system should include:

- a) original design criteria;
- b) configuration data (e.g. framing, number of legs, deck elevation);
- c) design data (e.g. reserve strength and residual strength);
- d) condition data reported from in-service inspection findings (e.g. performance of corrosion protection system, component degradation and/or deterioration);
- e) condition data reported from on-line monitoring;
- f) operational data (e.g. platform age, weight control data);
- g) fabrication data (e.g. fabrication welding quality and occurrence of rework);
- h) transportation/installation data (e.g. pile driving records, reported damage);
- i) SMR data (e.g. structural modifications and/or structural repairs/strengthening);
- j) analytical data (e.g. analysis results and assumptions on condition and criteria used in the original design or previous assessments);
- k) structural component capacity data (e.g. published capacity of tubular members or joints from laboratory tests);
- l) updated knowledge on geotechnical methods for determining soil capacity;

- m) criteria data (e.g. updated knowledge for metocean, seismic, ice and/or collision assessment actions);
- n) incident/accident data (e.g. fire, blast, collision, dropped object event or metocean, seismic, ice extreme or abnormal event);
- o) learning from similar platforms.

8.2 Missing data

If data is missing, this can force using conservative assumptions during inspection planning or an engineering assessment. This can lead to unnecessary inspections being performed or prevent upgrades being made and hence unjustly prevent potential development.

If the original design data or as-built drawings are not available, assessment data may be obtained by field measurements of dimensions and sizes of structural members and appurtenances.

Weight audits should be performed to monitor and validate the dry and operating loads, equipment layouts, laydown areas and other structures, where there is little or no ongoing weight monitoring and control.

8.3 Data management

The topside weight database should be maintained and kept up-to-date with weight, CoG changes and modifications (i.e. additions, relocations and removals). Proposed weight and CoG changes should be captured and communicated to the structural integrity engineer. Structural models and topside weight database should be kept synchronized.

Data management should be integrated across the stakeholders with differing overlapping structural integrity objectives, including:

- field concept development;
- front end engineering design;
- detail engineering design;
- fabrication;
- installation and hook-up;
- verification/classification;
- periodic inspection and monitoring;
- interventions to mitigate inspection findings that could compromise the structural integrity;
- periodic review of SIM – identifying trends and updating the inspection strategy;
- brownfield development from concept through to commissioning;
- decommissioning.

Data management should be integrated across disciplines, including:

- process equipment, tiebacks – weight control;
- pipeline/riser integrity – structural integrity of appurtenance supports and global loading;
- drilling and work-over campaigns.

9 SIM evaluation

9.1 General

Evaluation shall be performed throughout the total service life of the structure.

Evaluation of the structural integrity data shall be performed as new information/data is collected.

Evaluation shall be used as a basis for establishing or adjusting the inspection, maintenance and monitoring strategies (see [Clause 10](#)). The evaluation may address the overall structure or structural components where damage or adverse conditions have arisen or occurred.

Findings from the evaluation shall conclude either:

- that the structure, or critical structural components, is fit-for-service between inspections and requires on-going scheduled maintenance/monitoring/inspection (with a specified scope), or
- that remedial measures (immediate or longer term) are required.

9.2 Data evaluation

Evaluation should account for the SIM data collected in the manner recommended in [Clause 8](#).

In instances where the information/data recommended for inclusion as part of the evaluation is not available, an evaluation may be performed recognizing the inherent uncertainties and assumptions from the missing information. However, missing information/data can affect the evaluation and SIM strategy/program for the structure. Where structural data is not available, or the condition information/data is out-of-date, evaluation can provide a recommendation to survey the structure and facilities to collect the required information.

9.3 Hazards, hazardous events and degradation mechanisms

Evaluation shall include review of hazards, hazardous events and degradation mechanisms in accordance with ISO 19900.

NOTE Corrosion, fatigue, seabed scour and liquefaction are degradation mechanisms rather than hazardous events, and as such can reduce structural resistance.

9.4 Critical structure (CS)

CS is a part of the structure or structural components, loss of which will cause specific life-safety, environmental pollution or financial consequences. CS is typically a structural barrier that has been considered in terms of robustness to prevent an event from causing a major incident or is a structural barrier used to provide mitigation and de-escalation in the event of an incident.

CS identification and categorization should be used by the operator to understand the consequences of CS loss and should form the basis for risk-based SIM strategies recommended in this document.

9.5 Risk

9.5.1 General

The operator should adopt risk-based approaches to manage structural integrity. The structure or structural component risk should be established and used to optimize the inspection, monitoring or maintenance activities required to confirm fitness-for-service.

Risks are evaluated based on the product of the potential consequence (see [9.5.2](#)) and the estimated likelihood (see [9.5.3](#)).

Risks should account for the actions from hazardous events and degradation mechanisms causing reduction in capacity to resist the actions.

Risks evaluated as outside of the tolerable risk limit shall be managed through operational mitigations in conjunction with the inspection, monitoring and maintenance activities.

9.5.2 Consequence

Structure exposure level and limit states shall be reviewed during evaluation and amended to reflect any changes in data, such as change in use (e.g. conversion from manned to normally unmanned platform) or change in perceived risk (e.g. solitons or infragravity waves not considered significant at design phase considered significant in the operational phase following collection and assessment of additional data).

Additional limit states may be specified by the operator, including limit states (performance levels) that cover potential financial and reputational events.

9.5.3 Likelihood

SIM data should be evaluated to determine the likelihood of exceeding a limit state.

The likelihood that a structure will exceed an ALS hazardous event (metocean, ice, seismic, collision or some other foreseeable hazard) may be determined from an assessment of the structure against a range of return period abnormal/accidental actions or action combinations.

Likelihood of exceeding a limit state should be determined by quantitative methods, although qualitative or semi-quantitative methods may be used, see [12.3](#).

9.5.4 Risk presentation

Risk may be presented in a variety of ways to communicate the results of the analysis to decision-makers and inspection planners.

One goal of the risk determination is to communicate the results in a common format that each stakeholder can understand. This can be achieved by presenting the risk in the form of a matrix. The risk presentation should differentiate between the type of hazardous event and the consequence of exceeding the limit state.

9.6 Demonstrating fitness-for-service

The expectation is that the all criteria applicable in design (e.g. ISO 19902) should also be verified in assessment.

Assessment shall be documented with specific emphasis on assumptions made and calculations performed where the verification process differs from those specified in ISO 19900 and ISO 19902 (or ISO 19901-3^[2] or ISO 19906, as relevant), in the manner permitted below.

If one or more assessment criteria cannot be verified as acceptable (i.e. $UR > 1,0$), then site-specific data may be used in assessment verification, e.g. use of measured steel material properties rather than SMYS values, pile driving records from the installation phase, etc.). Linear-elastic and non-linear analysis methods may also be used to verify that the factored resistance exceeds the effects of factored actions or action combinations (as per ISO 19900).

The findings of the structural reliability analyses performed during the calibration of ISO partial safety factors may be used to justify modest reductions in the quoted safety factors for the site-specific design/assessment situation, e.g. the environmental action factor for an L1 exposure level structure specified in ISO 19902:2007, Annex H is a rounded up from the value calibrated and recommended.

Where site-specific data cannot confirm that all assessment criteria are verified, risk assessment may be performed in accordance with the operator's policies and procedures, or as agreed with

the regulator, as relevant. In this instance, risk assessment shall include quantitative calculation or qualitative estimation of the likelihood and consequence of exceeding the limit state concerned, and the risk mitigation measures to be performed.

Risk mitigation measures can include increased frequency and/or volume, monitoring, strengthening, installation of new safety barriers, unmanning, shut down of hydrocarbon flow and reduction of hydrocarbon inventory, etc. Physical risk mitigation measures should be favoured over analysis-based and procedural measures.

Approval of risk assessment and associated risk mitigation measures can involve disciplines beyond structural engineering and can also involve external organisations such partners and regulators. Consequently, any such requirements are beyond the scope of this document.

Several assessment methods are available for demonstrating that a structure or structural component is fit-for-service. These assessment methods include linear elastic analysis and nonlinear analysis approaches, see [A.9.6](#).

9.7 Assessment

9.7.1 General

The assessment is part of evaluation is illustrated in [Figure 3](#). Recommended methods of fitness-for-service assessment are provided in [Clause 12](#).

If the evaluation determines that the operational risk has become more onerous, some level of engineering assessment analyses shall be performed to determine whether the risks are tolerable or mitigation measures are required.

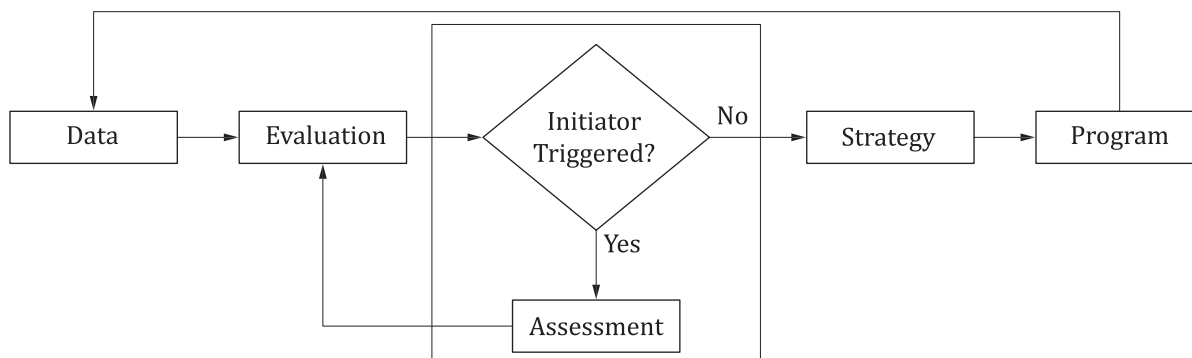


Figure 3 — Assessment within the SIM process

Assessment should use quantitative techniques to demonstrate that, for every hazardous event, the risks are tolerable. Assessment is typically step-wise with increasing complexity and is typically accomplished by performing a structural analysis of the structure or structural component.

If the evaluation indicates that the operational risk has increased, an assessment should be performed to determine whether the risks are tolerable or whether risk reduction or mitigation measures are required.

9.7.2 Assessment motive

Motives for performing a structural assessment vary and should be established prior to performing the assessment. The selection of the assessment method is influenced by the assessment motive, which can include:

- a) Supporting an evaluation - for structures where the evaluation has determined that an assessment of the structural strength is required, an assessment should be performed to demonstrate that the structure is fit-for-service.

- b) Categorizing the structural likelihood of exceeding the limit state; for risk-based SIM strategies an assessment should be performed to determine likelihood and provide input into categorizing the structural risk.
- c) Supporting an inspection program - an assessment should be performed to determine the structural locations required for inspection and for setting inspection anomaly threshold reporting requirements.
- d) Supporting a monitoring program - structures that have monitoring as part of their SIM strategies should be assessed to provide information on the threshold that would indicate a change in the structural condition. In situations where monitoring provides a life-safety mitigation measure the actions and triggering thresholds should be determined such that life-safety risk is maintained below the specified limit state.
- e) Supporting a mitigation strategy - structures that have included planned mitigation as part of their SIM strategies an assessment should be performed to provide information on the operating limits, which can include:
 - evacuation ahead of predictable events;
 - re-manning after an event;
 - hurricane preparedness;
 - triggering of monitoring action thresholds.
- f) Determining the probability of exceeding a limit state.

9.7.3 Assessment initiators

During evaluation, operator shall provide recommendations for changes that can increase the platform operational risk, including:

- changes in condition;
- changes in action;
- changes in criteria;
- changes in consequence;
- changes in use.

9.8 Mitigation measures

9.8.1 General

If it cannot be demonstrated that the risks are tolerable, risk reduction measures shall be implemented.

Procedures and plans shall be established in case of mitigation measures.

Risk reduction should be addressed at each stage of an assessment and may be used in lieu of a more complex assessment.

Mitigation of structural risk should be evaluated even if the life-safety, environmental pollution and financial risks are tolerable. If the risk reduction benefit exceeds the cost of implementing the mitigation the operator should perform the mitigation.

Mitigation measures may include structural modifications or changes in operational procedures that reduce loads, increase capacities or reduce the consequence of failure. Modifications to inspection and monitoring programs may be implemented to identify further deterioration.

Mitigation measures may be implemented in isolation or in conjunction with each other. The choice of measures and their extent depends on the source of risks to structural integrity and their magnitude.

9.8.2 Consequence reduction

9.8.2.1 Life-safety

Life-safety mitigation measures should involve permanently demanning the platform, or temporarily un-manning the platform during a forecasted extreme event.

9.8.2.2 Environmental

Consequence of failure mitigation measures should include one or more of the following:

- installation of subsea safety valves;
- removal or reduction of hydrocarbon storage or inventory volume;
- removal or re-routing of major oil lines;
- removal or re-routing large volume gas flow lines;
- permanently or temporarily abandon non-producing wells;
- isolation of the pipeline to reduce the potential volume of hydrocarbon release.

9.8.2.3 Abnormal storm preparedness

Advanced planning should be used to reduce abnormal storm risks as well as improve post storm response.

Abnormal storm preparedness plans should be developed covering general storm preparedness activities and structure-specific response activities.

Checklists and platform-specific guides can assist during the evacuation process.

9.8.3 Likelihood reduction

Likelihood reduction methods can include:

- increased inspection and/or monitoring;
- removal of a known damaged component;
- load reduction;
- localized strengthening and/or repair;
- global strengthening and/or repair.

10 SIM strategy

10.1 General

The operator shall develop a SIM strategy, which sets out the process for delivering the integrity management of its assets in line with the SIM policy and tolerable risks.

The SIM strategy shall identify the mitigation, monitoring and inspections to be included in the continuous risk reduction requirements for the structure and SC components.

The SIM strategy should be compiled into a document that is periodically reviewed and updated, including the evolving risks in the operation. The strategy should detail the program objectives and the targets that should be met to demonstrate fitness-for-service and continuous risk reduction. The strategy should identify the single points of accountability and responsibility for delivering the steps in the program.

Plans should reflect the overall SIM philosophy, which varies depending upon the design margins, field life, type of structure and sophistication of local infrastructure. These factors can influence the philosophical approach, affecting the extent of future maintenance activities as well as varying the degree of reliance between inspections and monitoring activities to demonstrate fitness-for-service.

For a new platform or platform reuse the overall SIM strategies should be developed during the early concept selection and front-end engineering stages of the design. Inspection, monitoring and maintenance plans should be developed during the later detailed design stages of a platform reuse, ideally performed early enough that potential plan implementation and execution issues can be addressed within the design. Additionally, development of the plans should include full participation of the operating team to confirm that the design, SIM strategy and SIM program are aligned.

SIM strategy should identify the frequency and type of activities required for the structural components. These activities should be based on maintaining the structural integrity of the SC components identified during the data evaluation.

10.2 Inspection strategy

10.2.1 General

An inspection strategy shall cover the total service life of the structure and structural components.

The inspection strategy shall provide the framework for the surveys.

The inspection strategy should account for the interdependence between the SIM process phases (see [Figure 2](#)).

The inspection strategy shall be a dynamic or a “living” document, meaning that inspection requirements can change due to inspection results or changes to the structure (e.g. changes in topsides dry and operating weight or CoG, discovery of damage and/or addition of new risers).

The inspection strategy should be periodically reviewed, and as required updated, throughout the total service life based on receipt and evaluation of new data/information (usually through amendments following the receipt of additional inspection reports, results of structure reanalysis or assessments, and other data or information pertinent to structural integrity).

The inspection strategy should be developed from the engineering evaluation (see [Clause 9](#)) that, when implemented, can determine within a reasonable level of confidence the existence and extent of deterioration, defects and damage.

The inspection strategy should address the topsides, substructure and splash zone, and should account for:

- inspection motives (see [10.2.2](#));
- inspection type (see [10.2.3](#));
- inspection method (see [10.2.4](#));
- inspection frequency (see [10.2.5](#));
- inspection scope (see [10.2.6](#)).

Scopes of work may be included in the strategy or may be developed as separate documents in accordance with the operator’s overall management framework.

10.2.2 Inspection motives

Inspection strategies should serve as proactive measures to detect damage and deterioration as well as provide information on the condition of the structure that should be used to confirm that the structural components remain fit-for-service.

10.2.3 Inspection type

10.2.3.1 General

SIM inspection strategy should account for scheduled inspections and unscheduled inspections.

10.2.3.2 Scheduled inspections

Scheduled inspections should include baseline inspections, periodic inspections and special inspections.

10.2.3.3 Unscheduled inspections

Unscheduled inspections should be performed to provide information on the structural condition following a potential overload event or incident. An unscheduled inspection should be performed as soon as practical after the occurrence of:

- a significant environmental event (e.g. storm, earthquake, mudslide);
- a significant accidental action (e.g. vessel impact, dropped object, explosion).

Well intervention or maintenance campaigns can increase the likelihood of accidental damage for the topsides. Therefore, these events should be treated as a potential overload case and a post-event inspection can be planned. Unscheduled post-event inspections should be developed based on an evaluation of the available data, including event/incident reports.

10.2.4 Inspection method

Inspection scope of work may include one or more of the following inspection methods to understand the condition of the structure:

- a general visual inspection (GVI);
- a close visual inspection (CVI);
- flooded member detection (FMD) complementing GVI and CVI;
- a non-destructive examination (NDE).

Selection of appropriate inspection method(s) for a given task shall be determined by qualified personnel based on the goals/objectives of the inspection and the sensitivity, effectiveness, reliability, cost, and availability of the various tools and techniques.

10.2.5 Inspection interval

10.2.5.1 General

SIM inspection strategy shall specify inspection intervals for:

- periodic above water inspection (see [10.2.5.2](#));
- periodic underwater inspection (see [10.2.5.3](#));

Periodic above water and underwater inspections should be performed at an interval consistent with the structural integrity strategy adopted by the operator. Underwater inspection intervals should be

developed using a risk-based approach. However, the consequence-based (default) inspection program based on worldwide experience provides a predefined in-service inspection program that may be used if operators choose not to implement a risk-based inspection strategy.

10.2.5.2 Periodic above water inspection

10.2.5.2.1 General

Above water inspection shall include the topsides structure and jacket structure above the waterline.

10.2.5.2.2 Consequence-based inspection interval

In the absence of a risk-based in-service inspection strategy, the topsides structure and jacket structure above the waterline shall be inspected annually using GVI.

Use of other inspection techniques (i.e. CVI and/or NDE) may be included with the annual GVI and should be selected based on the type of expected deterioration/degradation and the present known condition of the topsides CS. A CVI and/or NDE inspection should be performed when the GVI discovers deterioration/degradation and/or damage that require more detailed inspection to determine the extent and possible cause.

10.2.5.2.3 Risk-based inspection interval

Where the operator has adopted a risk-based structural integrity strategy, the topsides CS inspection intervals may be set that account for the risk associated with possible failure of the CS. The CS may be divided into system, sub-system or component level as required. Timing for the first risk-based topsides inspection should be determined from the completion date of the baseline inspection.

Risk-based intervals should account for the possible CS failure mechanisms and the associated deterioration/degradation mechanisms in the risk evaluation. The risk-based intervals should account for the following possible deterioration/degradation mechanisms:

- coating breakdown;
- corrosion;
- fatigue;
- fretting;
- erosion;
- passive fire protection (PFP) degradation;
- physical damage (e.g. vessel impact, dropped object);
- bolt loosening/failure;
- other material degradation.

10.2.5.3 Periodic underwater inspection

10.2.5.3.1 Consequence-based inspection interval

In the absence of a risk-based in-service inspection strategy, periodic underwater inspections shall be performed at intervals in conformance to [Table 1](#). The consequence-based inspection interval requirements only address the concerns of safeguarding human life and protecting the environment.

Table 1 — Underwater consequence-based inspection program intervals

Exposure level	GVI	CVI	NDE
L1 structures	Every 3 years	Every 6 years Or as determined from GVI findings	Determined from CVI inspection findings
L3 structures	Every 5 years	Every 10 years Or as determined from GVI findings	Determined from CVI inspection findings

10.2.5.3.2 Risk-based inspection interval

Timing for the first risk-based underwater inspection shall be determined from the completion date of the baseline inspection.

Platforms with higher consequence appurtenances can require more frequent inspection than that based on the structure's risk-based interval. In addition, the risk-based interval can require adjustment to account for the service life or present condition of the cathodic protection system.

Setting of intervals between inspections greater than 10 years requires the operator to demonstrate that:

- exposure level is L3;
- risk of exceeding all ULS and ALS have been quantified through a USM;
- inspection trends are understood;
- annual drop cell CP readings are performed and are acceptable.

Risk-based inspection intervals can be optimized through the use of a quantitative risk analysis that accounts for the annual risk of platform collapse from metocean or seismic hazards and the increase of this risk due to time-dependent degradation.

10.2.6 Inspection scope

Inspection strategy should develop scopes of work for each of the surveys specified as part of the inspection. The strategy should address the different inspection motives and should include scopes of work for:

- baseline inspection;
- above water periodic inspection;
- underwater periodic inspection;
- special inspection;
- unscheduled inspection.

For each survey identified as part of the inspection, a work scope should be developed which specifies the data recording and defect/anomaly reporting requirements. A system for reporting and documenting anomalies and defects should be in place so that data can be collected for an engineering evaluation.

10.2.7 Pre-selected inspection areas

Where the structural integrity strategy determines that CVI or NDE is required, the selection of the welded joints to be surveyed should include an evaluation of:

- data collected from the baseline survey;

- general inspection findings in the offshore industry;
- the significance of members and joints to the platform system capacity;
- the platform robustness and damage tolerance;
- joint and member stresses and stress concentrations;
- joint fatigue lives.

During design and subsequent assessment, member and joint action effects should be recorded and used to define requirements for future surveys.

10.3 Maintenance strategy

A structural maintenance program is a component of the overall SIM strategy, complementing the inspection and monitoring plans. Maintenance programs for structures should cover the corrosion control systems such as coatings and impressed current systems. The maintenance tasks and schedules should be developed based on good practices, equipment vendor guidelines and operator risk tolerance criteria.

Topsides structure is protected from atmospheric corrosion by the coating system which is applied during fabrication or commissioning. If the coating system is maintained during the total service life, a significant degradation mode that can reduce the load carrying ability of the structure will have been mitigated. A risk-based coating maintenance program will require that higher risk areas be painted first.

Maintenance strategy should account for:

- coating/fabric maintenance program;
- grating replacement schedule.

Maintenance should be specified accounting for the importance and use, knowledge of the durability of the components, environmental conditions and the protection against external actions. Structural components that are essential to the stability and resistance of a structure should, as far as possible, be accessible for inspection.

10.4 Monitoring strategy

10.4.1 General

Monitoring may be used in combination with an inspection plan to enhance the level and quality of condition and operation data used to confirm fitness.

If monitoring is used in lieu of scheduled inspections, the monitoring program shall be documented within the inspection plan to confirm monitoring program execution (i.e. occurring as planned, timely data evaluation and personnel competencies).

Different types of monitoring strategies can be implemented to address expected degradation due to defined mechanisms. Monitoring strategies should produce monitoring data regarding degradation rates or indicators for risk change, including:

- weight and CoG monitoring (see [10.4.2](#));
- deck elevation monitoring (see [10.4.3](#));
- natural frequency monitoring (see [10.4.4](#));
- corrosion protection monitoring (see [10.4.5](#));
- metocean monitoring (see [10.4.6](#)).

Monitoring programs often require specialty equipment, continuous data recording, periodic calibrations, plus specialty software and personnel to evaluate the data.

The project team and operating team shall confirm that adequate infrastructure and support can be provided to maintain the monitoring program in the long term.

Guidance should be provided on the specific activities that should be performed, when they should be performed, what should be measured, who is responsible for recording the data and maintaining it, and who should review, evaluate and communicate the results. Additionally, threshold criteria should be defined such that they indicate an anomalous condition that would trigger an evaluation.

10.4.2 Weight and centre of gravity (CoG) monitoring

Operational topsides weight should be managed by an operational weight management procedure that provides a basis for monitoring and assessing the magnitude and locations of loads.

Weight of topsides is likely to change during operational life due to modifications and upgrades. This should be monitored and managed through the introduction of periodic weight audits and following the weight control procedure.

Laydown areas should be monitored to confirm that the weight limits specified in the original design or assessments are not exceeded. Laydown areas are sometimes not included in an operational weight management procedure.

ISO 19901-5 provides recommendations that should be followed for typical procedures, common topside operating philosophy, drilling matrix, and list of coincident operating loads.

10.4.3 Deck elevation monitoring

Continuous monitoring of the deck elevation above a reference water level may be used as part of the structural integrity strategy. This may include GPS, differential tilt surveys, radar or other reflective signal technology.

10.4.4 Natural frequency monitoring

Continuous monitoring of the platform natural frequency may be used as part of the structural integrity strategy. Response characteristics should be compared over time to determine if the natural frequencies have decreased or if the mode shapes have changed. Changes in mass and the distribution of mass on the deck are a normal part of operations. These (and other effects) provide a background variation in response characteristics. If the response characteristics have changed, this can be attributed to some form of structural failure.

10.4.5 Corrosion protection monitoring

Results from CP and anode surveys should be monitored to determine if the corrosion protection system is working in line with design expectations. Monitoring and trending of corrosion protection can assist with early identification of issues by highlighting abnormal CP readings or increased anode usage.

10.4.6 Metocean monitoring

Metocean data may be monitored to confirm the actual environment a platform encounters (which may be used in subsequent fatigue assessments) and may help validate certain aspects of the original metocean basis of design.

10.5 Evacuation strategy

A personnel evacuation strategy should be developed if a performance standard is dependent on the personnel being relocated prior to the occurrence of a foreseeable event. The evacuation strategy

should account for the duration, the speed of development, the speed of movement and the extent of event conditions.

Advanced planning can reduce risks as well as improve post-event response. Written evacuation preparedness plans should be developed covering both general preparedness activities and structure-specific response activities. Checklists and platform-specific guides can assist during the evacuation process.

10.6 Marine site investigations

Marine site investigations should be available in conformance to ISO 19901-2, ISO 19901-4 and ISO 19901-8^[4]. Prior to performing an assessment, the marine site investigation engineering parameters should be reviewed and a new site investigation/analysis should be performed if the parameters are no longer valid or if data are missing (see 8.2).

11 SIM Program

11.1 General

The SIM program represents the execution of the detailed work scope and should be performed to complete the activities specified in the SIM strategy.

The SIM program shall include the activities defined within the SIM strategy over the total service life and include:

- an inspection program (see 11.2);
- a maintenance program (see 11.3);
- a monitoring program (see 11.4);
- a reuse program (see 13);
- a decommissioning and removal program (see 14).

To complete the SIM process, data collected during the SIM program should be incorporated back into the SIM data management system. Consistency, accuracy, and completeness of inspection, maintenance and monitoring records are important, since the data form an integral part of the SIM process. Specific requirements for the execution of the work scope, including data recording and reporting requirements, should be defined within the inspection, monitoring and maintenance plans.

11.2 Inspection program

11.2.1 General

If anomalies are discovered that can potentially affect structural integrity, conductors, risers and J-tubes or appurtenances, personnel should perform an evaluation to determine if additional inspection and/or remedial measures should be performed. Additional inspection can require use of more detailed survey techniques.

If above water damage is detected, NDE should be used when visual inspection cannot determine the extent of damage. If the above water inspection indicates that underwater damage is possible, an underwater inspection should be performed as soon as conditions permit.

11.2.2 Specifications

Inspection program should establish specifications for inspection activities and establish procedures for quality assurance, quality control, and data validation.

Inspection specification should, as a minimum, include:

- anomaly reporting requirements;
- diver and ROV operator qualifications;
- NDE technician qualifications;
- notification requirements following discovery of an anomaly (e.g. flooded member);
- measurement procedures (e.g. dents, bows, holes);
- sensors and instrumentation;
- reporting formats and procedures;
- photography and video recording procedures.

11.2.3 Inspection method

11.2.3.1 General

Selection of an inspection method(s) for a given task shall be determined by qualified personnel based on the goals/objectives of the inspection and the sensitivity, effectiveness, reliability, cost, and availability of the various tools and techniques.

11.2.3.2 General visual inspection (GVI)

GVI shall be performed to determine the condition of the members, joints, or components selected for inspection.

If above water damage is detected, a record of the damage should be made to allow engineering personnel to determine if repairs or further inspection (e.g. NDE) are required.

Damage records should include measurements, photographic documentation, and drawings. If the above water survey indicates that underwater damage could have occurred (e.g. a missing boat landing or unrecorded damage exists), an underwater inspection should be performed as soon as conditions permit.

11.2.3.3 Coating survey (including passive fire protection)

Coating survey shall be performed to detect deteriorating coating systems and corrosion.

The survey should report the type of coating systems for the components inspected (i.e. Monel cladding or elastomers on the splash zone members and jacket legs, paint on the conductors) and record the locations and extent of coating deterioration. ISO 4628^[1] may be used for specifying the degree of rusting of coatings by comparison with pictorial standards.

11.2.3.4 Survey of underwater cathodic protection

Survey of the underwater cathodic protection shall include a below water measurement over the water depth of the cathodic protection system by silver/silver chloride drop cells or other approved drop 057 accepted cells.

The reference cell should be within 1,0 m of the structural component being inspected.

11.2.3.5 Appurtenance and personnel safety devices surveys

Appurtenances and personnel safety devices include handrails, grating, stairs, swing ropes, boat landings, helideck, bridges, supports to risers, survival craft supports, crane pedestals, communications tower deck connections, and structural elements supporting evacuation routes and TR.

11.2.3.6 Air gap survey

In operational areas of known or suspected subsidence, the above water inspection shall include a survey of the gap between the cellar deck bottom of steel and the water level. For other areas, the deck elevation should be measured on a periodic basis to provide up-to-date information.

For accurate air gap measurements, wave radars should be used. Alternatively, measurements may be made with a plumb line and recorded against the time of measurement to allow later agreement with tidal information or changes. Suspected subsidence or differential settlement of the structure should be recorded.

11.2.3.7 Close visual weld/joint survey

The close visual weld/joint survey should be used to detect and size visual cracks in or adjacent to the weld and confirm the extent of corrosion of the steel surface and areas adjacent to the weld.

11.2.3.8 Damage survey

If damage is found during the visual survey, a follow-up survey should be performed to obtain data for the damage evaluation. The survey should identify the location and should include dimensional measurements to measure such quantities as damage size and geometry, member out-of-straightness, crack length and depth, corrosion pit size, etc. The survey should be extended to inspection for collateral damage (e.g. a heavily dent-bowed member, bulging or buckled could have cracks at the member ends).

11.2.3.9 Supplemental surveys

Above water inspection may include supplemental surveys to characterize damage as specified in the scope of work (e.g. NDE, material sampling, wall thickness measurements).

Bolt tightness checks should be performed to confirm that the bolt nuts used for connecting and attaching topsides components are not loose.

A settlement and tilt survey should be performed during the scheduled above water inspection. Settlement can induce stresses in the platform members and at the deck structure, and can be precipitated by seabed subsidence. Differential settlement in case of fixed platform can induce stresses at the deck structure.

Unmanned aerial vehicles (UAVs) may be used for high-altitude inspections on structures (e.g. flare booms and drilling towers). However, such surveys should be verified and certified for reliability and fit-for-service.

11.3 Maintenance program

Maintenance activities should follow the program specified in the maintenance strategy. The most important facet of a maintenance program is being proactive and preventative. Not completing maintenance tasks or associated repairs can result in a “reactive” program, increasing the risk of failures and diminishing the fitness-for-service of the structure.

As part of the inspection plan work scope and structural integrity program reviews, checks should be made to confirm that critical maintenance has taken place. If the maintenance has not taken place the affected CS should be treated as in an anomalous condition. Actions should be taken to work off the maintenance backlog and confirm execution of future tasks.

11.4 Monitoring program

As the monitoring data are collected, the information should be reviewed to determine whether anomalous conditions exist that would warrant further evaluation. The data review should be performed periodically based on the monitoring plan.

As part of the inspection plan work scope and structural integrity program reviews, checks should be made to confirm that the essential elements of the monitoring plan (e.g. data collected, post-processed) are taking place. If the maintenance has not taken place, the affected CS should be treated as in an anomalous condition. Similarly, if the monitoring device is damaged or not functioning, the affected CS should be treated as an anomalous condition. In either instance, actions should be taken to reinstate the monitoring plan and the anomalous condition evaluated based on the SIM processes recommended in this document.

12 Assessment

12.1 General

Assessment should use quantitative or semi-quantitative techniques to demonstrate that, for every hazardous event specified, the structure and structural components, including the jacket primary structure and foundations, does not exceed the specified limit states.

An assessment should include the following:

- establish motive for assessment (see [9.7.2](#));
- gather assessment information (see [12.2](#));
- select assessment method (see [12.3](#));
- generate assessment model (see [12.4](#));
- perform assessment (see [12.5](#), [12.6](#), [12.7](#), [12.8](#), [12.9](#), [12.10](#) and/or [12.11](#));
- determine if the assessment verifies the limit state assessment criteria.

Assessment is typically step-wise from qualitative methods, if applicable, to quantitative analysis methods with increasing complexity but reducing conservatism. If verification of all the limit state criteria is not achieved, then the assessment may be re-performed with a more complex, but less conservative analysis method.

An assessment should demonstrate that the structure achieves the limit state verification.

For structures that do not achieve the limit state verification, risk reduction options shall be initiated that either reduce the likelihood (prevention) and/or reduce the consequence (mitigation).

12.2 Assessment information

Structure should be assessed based on its present condition, accounting for damage, repair, scour, seabed subsidence, or other parameters potentially affecting its fitness-for-service. The operator should verify that assumptions made are reasonable and that the data is accurate and representative of actual conditions at the time of the assessment, or for future modifications.

Data should be up-to-date and reflect the condition at the time of the assessment. This information should be available from the SIM data management system (see [Clause 8](#)).

12.3 Assessment method

12.3.1 General

Assessments may use semi-quantitative or quantitative methods that can include using:

- simplified procedure;
- platform similarity;

- previous assessment;
- prior exposure;
- design level methods;
- ultimate strength methods;
- structural reliability methods.

Structural reliability methods are not a requirement of this document. However, for structures requiring a more complete assessment structural reliability can be used.

Selection of the assessment method should be based on [Table 2](#).

12.3.2 Qualitative method

Likelihood of exceeding a limit state may be established using a qualitative method that uses judgment, experience and knowledge on the structural aspects to categorize the structure or structural component.

Table 2 — Assessment method selection

	Method								
	Semi-quantitative				Quantitative				
					Design level		Ultimate strength		
	Simpli- fied pro- cedure	Similar- ity	Previous assess- ment	Prior expo- sure	Line- ar-elas- tic anal- ysis ^{a,c}	Line- ar-elastic redundan- cy	Static non- linear analysis	Dynamic nonline- ar analy- sis ^d	Struc- tural re- liability analysis ^e
	Increasing complexity  Reducing conservatism								

Assessment trigger									
Change in platform condition					Yes	Yes	Yes	Yes	Yes
Change in estimated actions ^b	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Change in assessment criteria	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Change in conse- quence					Yes	Yes	Yes	Yes	Yes
Change in use					Yes	Yes	Yes	Yes	Yes
Assessment motive									
Support evaluation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Categorize likelihood	Yes		Yes	Yes			Yes	Yes	Yes
Support inspection program							Yes	Yes	Yes
Support mitigation strategy							Yes	Yes	Yes
Determine probability									Yes

^a Linear-elastic analysis with nonlinear foundations.
^b Change in actions due to WiDA can require the use of a nonlinear assessment method.
^c Includes seismic response spectra analysis.
^d Includes seismic time-history analysis.
^e Not a requirement of this document.

12.3.3 Semi-quantitative method

12.3.3.1 General

Likelihood of exceeding a limit state may be established using a semi-quantitative method that categorizes a structure based on a set of rules relative to other similar structures. The ranking system

should determine a likelihood based upon key information that accounts for the strength, and the extreme, abnormal or accidental action.

Likelihood categorization system should identify the parameters affecting structural strength and actions (e.g. platform type (drilling, production, wellhead), year designed, number of legs, bracing scheme, water depth). Parameters that indicate the strength has deteriorated or is not up to present standards increase the likelihood of exceedance. In addition, parameters that indicate that extreme, abnormal and accidental actions can increase in frequency or severity increase the likelihood.

12.3.3.2 Simplified procedures

Simplified procedures exist for the fitness-for-service evaluation of existing structures. The use of these procedures requires knowledge of the assumptions upon which they were based, as well as an understanding of their application and limitations. The loadings used in a simplified procedure should be validated as being conservative compared to the quantitative methods recommended in [12.3.4](#).

12.3.3.3 Previous assessment

A previous assessment of a structure may be used if the analysis represents the present configuration and condition of the structure, and represents the applied actions to verify the limit state.

If a USM is required by the assessment initiator, a previous DLM shall not be used.

12.3.3.4 Prior exposure

An alternative to a quantitative assessment is to use prior event exposure, provided the structure has survived with no significant damage. Prior exposure uses the survival of an event that is known with confidence to have been as severe as, or more severe than, the event required to demonstrate limit state verification.

For metocean or seismic events, prior exposure should be performed by comparing the expected maximum base shear to which the platform has been exposed, from measurements or calibrated hindcasts, with the base shear required for the limit state verification.

Prior exposure comparison should account for:

- uncertainty of the prior exposure event actions;
- uncertainty in the platform ultimate strength;
- degree to which the platform's weakest direction was tested by the prior exposure actions;
- possible changes in condition and/or topsides weight or CoG since the prior exposure.

12.3.3.5 Similarity

Assessment results for one structure may be used for another structure if the structures are similar with respect to jacket framing, steel material, soil properties and pile geometry, structural condition, topside mass and geometry, water depth and actions.

An assessment based on similarity shall not use a structure which itself has been demonstrated as fit-for-service based on an assessment by similarity.

12.3.4 Quantitative methods

12.3.4.1 General

Likelihood of exceeding a limit state may be established using a quantitative method that uses explicit probabilities, or implied probabilities based on a DLM to categorize the structure or structural component.

12.3.4.2 Design level method (DLM)

DLM is the method used for designing new platforms, as recommended in ISO 19902, where a structure is designed on a component-by-component basis.

DLM should be performed using linear analysis with nonlinear soil springs. DLM may be performed for the ULS and/or the ALS. The ISO 19902 ALS includes WiD action effects. Therefore, if the ALS is used to demonstrate that the structure achieves the limit states it is not necessary to undertake a USM (nonlinear) assessment. Also, the ALS may be used in-lieu of a ULS.

A reference action vector with partial action factors should be used together with a characteristic capacity and partial resistance factors to give a design action and a design capacity. If the design capacity exceeds the design action effect, the component has achieved the limit state.

12.3.4.3 Ultimate strength method (USM)

12.3.4.3.1 General

USM should be performed using static or dynamic nonlinear analysis techniques that include material nonlinearity and geometric nonlinearity by finite displacement or finite strain theory to determine the maximum actions that the structure can sustain with in the relevant limit state.

USM involves performing an assessment of the structure's capacity, as opposed to the component assessment used in a DLM. Local failure of structural members, joints or foundations is inconsequential if the structure's capacity achieves or exceeds the required limit state.

Provisions in this document for the ultimate strength method generally apply to structures where a static analysis adequately represents structural response. For dynamically sensitive structures, a dynamic, time domain, nonlinear pushover analysis may be utilized.

Cyclic degradation of the member capacity, joint capacity and soil capacity should be represented by an evolving force-deformation relationship.

12.3.4.3.2 Static nonlinear analysis

Nonlinear methods are intended to demonstrate that a structure has adequate strength and stability to withstand the ultimate strength loading. Local overstress, and member or joint failure may be predicted, without global collapse. At this level of analysis, stresses have exceeded linear levels and modelling of overstressed members, joints, and foundations should adequately recognize ultimate capacity as well as post-buckling behaviour, rather than linear action limits.

Ultimate strength is typically determined using nonlinear structural analysis software, which applies an incrementally increasing lateral action to the structural model until limit state is met. The lateral action should be representative of the actions acting on the structure at the limit state.

12.3.4.3.3 Dynamic nonlinear analysis

A dynamic nonlinear analysis may be performed as a more accurate assessment option to a static nonlinear analysis when dynamic response is significant or when damage is predicted to occur during the duration of the hazardous event (e.g. to confirm no collapse occurs during the highest and subsequent waves in the abnormal storm or the highest and subsequent accelerations in an abnormal earthquake).

Dynamic nonlinear analysis involves performing an analysis in the time-domain using the time-history action vector for a given return period of the hazard. Member or joint fracture due to low cycle fatigue should be included in the evolving the force-deformation relationship.

12.3.4.3.4 Structural reliability analysis (SRA)

SRA may be used to assess the limit states of a structure including the effects of uncertainties in the actions, resistances and modelling. The inherent or physical randomness in the basic variables (known as aleatory randomness) should be represented together with epistemic uncertainties originating from lack of sufficient data and shortcomings in the model's representation of reality. Epistemic uncertainties can be reduced by collection of more data or by further investigation regarding the modelling of actions or the modelling of resistance.

12.3.5 Fatigue analysis

Dynamic spectral fatigue analysis (ISO 19902) is typically used to determine the fatigue lives at tubular joint welds and circumferential welds on tubular members. Deterministic fatigue analysis or time-history fatigue may be used.

In addition, the following should be used to avoid the calculated fatigue lives being overly conservative:

- local joint flexibility;
- realistic rather than conservative loading of members' subject to intermittent wetting near the water surface;
- application of the hydrodynamic load on members near the water surface by multiple vertical diagonal segments to accurately model the rapid attenuation of hydrodynamic load with depth;
- use of MacCamy-Fuchs^[34] method to determine the C_m as a function of wave frequency for large diameter legs.

Actions should be based on the actual structural configuration over the period being assessed (e.g. actual number of conductors or risers, drill rig and position). Future planned or temporary actions should be assessed.

As part of the evaluation/assessment process for future total service life, accumulated fatigue degradation effects may be calculated.

Where CVI and/or NDE underwater inspections are made and known damage is assessed and/or repaired, fatigue analyses may not be required before the next inspection interval.

Underwater non-destructive inspection of a welded joint may be used to reduce estimated accumulated fatigue degradation if there is no evidence of surface cracking. This information may be used to establish an acceptable RBI interval that accounts for the inspection method and length of in-service exposure of the weld to fatigue. Monitoring fatigue-sensitive joints, and/or reported crack-like indications, is an acceptable alternative to analytical verification.

12.4 Assessment model

12.4.1 General

The assessment model should accurately represent the structural configuration and should account for the present condition as reported from the condition assessment (see 12.2).

12.4.2 Tubular members

Assessment of the resistance of structural tubular members shall be performed in conformance to ISO 19902.

In addition:

- a) Tubular members should be modelled using local joint flexibility (see UK HSE report 2001/056^[46]).

- b) For structures in regions subjected to low temperatures, the fracture resistance of exposed connections made of steel not originally specified for low temperature service should be included in the resistance model.
- c) Approach to member and joint resistance should be adopted for nonlinear analysis methods and:
 - computed peak axial load of critical compression members should be calibrated, by adjusting the initial lateral imperfection, to match the mean of test data for capacity of tubular columns, in conformance to ISO 19902;
 - post-peak axial load versus end shortening of tubular compression members should include the effects of local plastic buckling.

12.4.3 Connections

Strength of connections should be represented in the analysis model in conformance to ISO 19902. For tubular joints in tension, first cracking capacity should be used. Nonlinear shell element models, embedded into the beam element model of the platform, may be used.

12.4.4 Conductors

Conductors (drilled and grouted or driven) should be modelled with p-y springs and should be included in the assessment model. The conductors provide additional lateral foundation support to the platform system and the conductor guide framing should be modelled to account for conductor loading to the jacket.

12.4.5 Damage

12.4.5.1 General

Residual capacity of a damaged component may be determined through simplified methods or detailed analytical techniques. The residual capacity of the component may be used in the evaluation of the system capacity.

12.4.5.2 Dented tubular members

Axial capacity of a transversely loaded brace can be reduced due to the presence of a dent. In offshore structures, braces are susceptible to wave loadings, particularly near the water surface, where wave slamming during storms can impose lateral loading on these members. Tubular members under an impact event can suffer denting and bowing of the member. The most significant geometrical parameter affecting residual strength is the dent depth.

Effects of member bowing on the capacity of the member may be incorporated by using the out-of-straightness of the damaged member. For an initial assessment, the dented member should be treated as unable to carry the load.

Dented tubulars may be modelled explicitly using nonlinear software by simulating a collision using a shell element model or a beam element model (if the software has the capability to represent dents in beam elements).

12.4.5.3 Uniformly corroded tubular members

A reduction in the thickness of a member may be used to model the reduction in strength for uniform corrosion. Thickness reduction should be consistent with the quantity of material removed due to corrosion. Member should be evaluated as an undamaged member with reduced wall thickness. Using minimum local thickness (i.e. averaged over the worst 60-degree arc) is conservative even though the reduction in thickness is not constant throughout the member length.

12.4.5.4 Locally corroded tubular members

Localized corrosion (i.e. pitting and/or holes) can reduce the member capacity. In lieu of a refined analysis, the strength of members with severe localized corrosion should be assessed by treating the corroded part of the cross-section as non-effective and using methods like those provided in [12.4.5.2](#) for dented members.

12.4.5.5 Cracked tubular members

Static tensile strength of a partially cracked tubular joint may be estimated by reducing the affected joint strength by some fraction, or by removing the member/joint weld connection from the structural model.

Provided the material is ductile under service conditions, the reduced joint strength may be estimated from simple methods, based on the use of reduced area or section modulus in proportion to the lost area on the failure surface, or based on more extensive numerical analysis using finite element analysis models or experimental evidence.

Partially cracked tubular members can reduce member capacity. In lieu of a refined analysis, a partially cracked member with the cracked area loaded in compression can be treated in a similar manner to that of a dented member (i.e. using a reduced capacity). For tensile loads or tensile bending moments, an engineering fracture mechanics assessment may be used as part of the assessment.

If a cracked joint or member is in tension for the pushover event, it should be demonstrated that its capacity will not be degraded by low cycle fatigue during the RP storm, unless such degradation is represented in the structural analysis.

12.4.6 Repaired and strengthened elements

Members and joints element properties should be modified to account for the local or global effects of repair/strengthening.

12.4.7 Foundation model

12.4.7.1 General

The soil resistance model for piled (drilled and grouted or driven) foundations shall be in conformance to ISO 19901-4.

12.4.7.2 Pile capacity

Analyses shall be performed using the following:

- a) DLM - characteristic soil parameters;
- b) USM - best estimate (mean) or characteristic soil parameters in in conformance to ISO 19901-4.

The ultimate capacity of the pile shall be the cumulate of the t - z springs at compatible z displacements down the pile length plus the end bearing (q) for the compatible z at the pile tip.

The sum of the peak t and the peak q overestimates the soil capacity, if they do not occur at the same pile head displacement. Static p - y curves for lateral soil response should be used for ultimate strength assessments.

12.4.7.3 Available soil data

A soil boring that was not drilled at the location of the platform or was not drilled using modern methods of sampling and testing may be used. However, the validity of the sampling techniques should be determined, and if a nearby boring is appropriate for the platform location, otherwise a site-specific boring should be used.

12.4.7.4 Pile driving records

Pile driving records as well as soil boring logs may be used to provide additional insight on the soil profiles at each pile location, and to infer the elevations of pile end bearing strata. The records can assist in re-estimating the axial pile capacities. Although not always available, these records are useful for verifying the soil stratigraphy or the final pile penetration. If pile driving records are used the pile hammer performance should be reviewed (see ISO 19901-4).

12.4.7.5 Piles

Piles shall be included in the assessment model using an approach that represents the soils using nonlinear springs (p - y , t - z and Q - z).

The assessment model may account for a conservative (i.e. lower bound) effect of ageing on pile capacity (see [A.12.4.7.2](#)) and a continuum model for the soil may be used.

To represent the vertical soil displacements down the pile length, the pile axial flexibility shall be modelled (rather than rigid piles), see ISO 19901-4.

Piles should be modelled to include the structural effects of jacket leg extensions below the seafloor.

For linear-elastic analysis with nonlinear foundations and for static nonlinear analysis, the analysis shall include cyclic degradation at the event RP and loading rate enhancement.

For a dynamic nonlinear analysis, the soils should be represented:

- using elasto-plastic springs (p - y , t - z and Q - z) with hysteretic damping and post-holing (i.e. formation of a gap around the pile, if any);
- with radiation soil damping when a seismic analysis is performed;
- with cyclic softening of the soil in the evolution of the elasto-plastic soil springs (p - y , t - z and Q - z) in time.

12.4.7.6 Pile groups

Representing pile groups shall account for vertical and lateral pile group efficiency at the ultimate capacity of the pile group.

Soil springs (p - y , t - z and Q - z) shall be defined for the displacement magnitudes that can be realized in the analysis as the piles plunge or pull-out.

12.4.7.7 Mudmats

Additional contribution to pile capacity from mudmats may be included, but should be limited to the total soil capacity due to pile loading combined with mudmat loading. Mudmats should not be included in areas where the soils are granular and are liable to scouring.

12.4.8 Material strength

If data is available, the actual (coupon test or mill certification) or mean yield strength may be used instead of specified minimum yield strength (SMYS).

12.5 Assessment for gravity hazard

12.5.1 General

If weighing records of the topsides are not available, then the calculated topsides permanent action should be used. The mean permanent and mean variable topsides action should be used. Coincident operational actions, including drilling actions, should be applied in conformance to ISO 19901-5.

12.5.2 Design level method (DLM)

Permanent and variable actions for assessment should be determined in conformance with ISO 19901-5.

12.5.3 Ultimate strength method (USM)

A static nonlinear analysis may be used to verify the limit state against the gravity load hazard for soil and structure in stillwater conditions at a system level rather than at the component level as in the stillwater DLM. In a static nonlinear analysis for the stillwater the permanent dead actions, variable actions and stillwater buoyancy should be initially applied followed by incrementing the permanent dead actions and variable actions until the platform collapses.

A static nonlinear analysis should be performed where critical components of the structure have a dead action (permanent and variable) to metocean action ratio of 80 % or more and these components have URs exceeding unity in a stillwater linear-elastic analysis. The static nonlinear analysis for the stillwater should be used to verify the limit state (as a system) for the gravity load hazard in stillwater conditions can be achieved by local yielding and redistribution with strains limited to the tearing limits recommended in ISO 19900.

12.6 Assessment for metocean hazard

12.6.1 General

Prior to performing an assessment of the structure, and prior to performing complex analyses, such as a static or dynamic nonlinear analysis, the quality, methodology and accuracy of the metocean analysis (including the amount and quality of raw metocean data) should be evaluated.

In some shallow water locations, the system strength of platforms with large decks can be governed by wind actions, rather than wave and/or current actions. In such cases, the platform system capacity should be assessed against the maximum wind criteria in combination with the associated waves, currents and surge.

12.6.2 Metocean criteria

Metocean analysis should account for the following:

- independent extremes of the metocean variables (e.g. wave, winds, currents and crest elevations);
- long-term distribution of metocean processes (i.e. annual distribution of storm peaks sea states);
- short-term distribution of metocean processes (i.e. distribution of crests in a sea state);
- relevant parameters associated with extremes (i.e., wind speed, current speed and depth, wave heights, wave periods, kinematics factors).

Independent extremes should be determined in conformance to the approaches recommended in ISO 19901-1.

12.6.3 Crest elevation

When assessing air gap, the annual probability of exceedance of the total water surface elevation shall be determined by an approach that includes the combined probabilities of:

- exceedance of the stillwater-level (including storm surges, astronomical tides);
- settlement and subsidence of seabed;
- wave crest height including spatial statistics to account for finite deck area (different from point statistics);

— change in water-level.

Wave crest height distribution shall be determined in conformance to ISO 19901-1.

12.6.4 Metocean action combinations — Jacket

Metocean action combinations shall be calculated in conformance to ISO 19902 accounting for variations in magnitude and direction.

To avoid excessive conservatism, the wave, current and wind parameters may be determined from a response based metocean analysis as recommended in ISO 19902.

A response-based metocean analysis determines the coexisting wave, current and wind parameters that, when input to a metocean action calculation, will produce the most realistic exceedance estimate of action with the required return period. Other forms of metocean analysis involving inputting wave, current and wind parameters, with defined return periods, will typically result in a larger metocean action than that determined by the response based analysis.

Wave actions on a platform are dynamic in nature. For most design water depths, these actions may be adequately represented by their static equivalents. For deeper waters (i.e. greater than 122 m), or where platforms are more flexible (i.e. natural period greater than 3 s), or the platform is damaged, an inertial action should be applied or a dynamic analysis performed. The inertial action should be determined in conformance to ISO 19902.

12.6.5 Metocean action combinations — Deck

Unless it is demonstrated that the air gap is sufficient to avoid wave-in-deck impact, the assessment shall include metocean action combinations for the deck.

WiD load effect shall be added to the maximum jacket load effect unless it can be demonstrated that these effects should be separated in time, based on an appraisal of the time history results.

WiDA shall be based on analysis of the interaction between wave event and deck structure (e.g. geometric modelling of the underside of the deck, including girders that affect the WiDA) by using either:

- model test results;
- momentum flux that accounts for the spatial and temporal convergence; or
- computational fluid dynamics (CFD) that accounts for the spatial and temporal convergence, and possible effects of compressed air;
- silhouette method.

For L1 structures, the primary mitigation strategy for the wave-in-deck actions should be raising the deck. Other mitigation strategies may be deployed that either reduce the likelihood or reduce the consequence (see 9.10).

12.6.6 Directionality of metocean hazards

In some locations, representative storm tracks and topographic features can provide fetch limitations on wave heights from specific directions, or tidal or general circulation currents can be in a predominant direction. For assessment in such situations, different wave, wind, and/or current magnitudes may be used for different approach directions, provided data are available to derive them.

However, the operator shall confirm that the overall reliability of the structure is not compromised by using lower directional environmental conditions.

12.6.7 Design level method (DLM)

12.6.7.1 Ultimate limit state (ULS)

ULS should use E_{100} to determine the URs, with characteristic capacities for structural components and characteristic soil parameters (see ISO 19901-4), together with partial action factors and resistance factors in conformance to ISO 19902.

To achieve the limit state, URs of members and joints shall not exceed unity.

Axial capacity of a pile is acceptable if the capacity of the foundation system, with partial resistance factors in conformance to ISO 19902, can resist the applied actions. In addition, the deck elevation is required to exceed the elevation of the wave crest for the wave with return period of RP years.

12.6.7.2 Abnormal limit state (ALS)

ALS should use E_{RP} to determine the URs, with characteristic capacities for structural components and soil, together with partial resistance factors of unity and partial action factors of unity. Deck elevation is not required to exceed the elevation of the wave crest for the wave with return period of RP years.

URs of members and joints shall not exceed unity.

Axial capacity of a pile is acceptable if the capacity of the foundation system can resist the applied actions.

12.6.8 Linear-elastic redundancy method

Linear-elastic redundancy method is similar to the ALS option of the DLM, but is performed by removing members or joints with a UR > 1,0, until the URs of remaining members and joints are less than unity.

Other equivalent linear methods can be used, if they can be justified to provide conservative or similar results as nonlinear methods.

12.6.9 Ultimate strength method (USM)

12.6.9.1 General

USM shall:

- include an inertial dynamic amplification factor (DAF) in accordance with ISO 19902;
- use mean (best estimate) values for structural component resistance parameters;
- use mean (best estimate) values for soil strength parameters.

12.6.9.2 Static nonlinear analysis

A metocean static nonlinear analysis should be initiated by incrementally applying the metocean action E_{RP} , where E_{RP} is the metocean action combination having the required return period. The static nonlinear analysis requires the structure not to collapse when E_{RP} is applied and the strains are within the tearing limits recommended in ISO 19900.

A static nonlinear analysis should be performed for each wave direction or by use of the omnidirectional metocean action E_{RP} .

12.6.9.3 Dynamic nonlinear analysis

A metocean dynamic nonlinear analysis (or time-history analysis) may be performed for the critical wave sector directions. The annual probability of platform collapse is the sum of the directional probabilities of platform collapse.

Dynamic nonlinear analysis (or time-history analysis) should use the following manual iterative approach:

- select a trial RP;
- determine the time varying WiJA for the selected RP;
- determine the corresponding WiDA time history, and factor to account for uncertainty;
- apply the time varying WiJA together with the WiDA time history.

Demonstrating that the platform has a return period to collapse of RP years requires the platform not to collapse during the dynamic nonlinear analysis. Component and joint strains should remain within the tearing limits recommended in ISO 19900.

12.7 Assessment for seismic hazard

12.7.1 General

Prior to performing an assessment of the structure, and prior to performing complex analyses, such as dynamic nonlinear analysis (or time-domain), the quality, methodology and accuracy of the seismic probabilistic seismic hazard analysis should be evaluated.

Seismic hazard curves should be developed by a probabilistic seismic hazard analysis in accordance with ISO 19901-2 that give the magnitude of the spectral acceleration as a function of return period of the hazard.

12.7.2 Seismic criteria

Accelerations should be calculated and applied down the full length of the pile. If non-depth varying accelerations are used, then the seafloor time-history should be applied uniformly down the full length of the pile. Depth varying response spectra at the natural period of interest should be compared to verify that the seafloor time-history provides the highest accelerations.

Gravity actions due to normal operational conditions, including 75 % of the variable actions $Q1$, shall be applied in conjunction with the seismic actions.

Topside mass should be represented, with the correct vertical and horizontal CoG. Jacket mass should be represented, with the mass of entrapped water and the added hydrodynamic mass included (i.e. marine growth).

12.7.3 Seismic action combinations

Seismic action vector should be calculated using the procedures recommended in ISO 19902 and ISO 19901-2. The seismic hazard curve (for the dominant natural period of the platform) should be determined from a site-specific probabilistic seismic hazard analysis as recommended in ISO 19901-2.

Selection and scaling of the acceleration time-history should be based on ISO 19901-2, including:

- use of linear scaling, spectral matching or a conditional mean spectrum (see Reference [33]);
- period range of interest;
- orientation of ground motion components;
- sites close to controlling active faults.