Risk-Based
Structural Integrity Management
for Topside Structures

October 2018
NI 653 DT R00

Guidance Note

BUREAU VERITAS

RULES & GUIDANCE NOTES

BUREAU VERITAS MARINE & OFFSHORE

GENERAL CONDITIONS

1. INDEPENDENCE OF THE SOCIETY AND APPLICABLE TERMS

1.1 The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.

1.2 The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not, in any circumstances, involve monitoring or exhaustive verification.

1.3 The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, designer, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of them above listed being relieved of any of their expressed or implied obligations as a result of the interventions of the Society.

1.4 The Society only is qualified to apply and interpret its Rules.

1.5 The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.

1.6 Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the Rules applicable at the time of entering into the relevant contract for the performance of the Services.

1.7 The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

2.1 **"Certificate(s)"** means classification or statutory certificates, attestations and reports following the Society's intervention.

2.2 **"Certification"** means the activity of certification in application of national and international regulations or standards, in particular by delegation from different governments that can result in the issuance of a Certificate.

2.3 **"Classification"** means the classification of a Unit that can result or not in the issuance of a classification Certificate with reference to the Rules. Classification is an appraisement given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules or to the documents of reference for the Services provided. They cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

2.4 **"Client"** means the Party and/or its representative requesting the Services.

2.5 **"Conditions"** means the terms and conditions set out in the present document.

2.6 **"Industry Practice"** means international maritime and/or offshore industry practices.

2.7 **"Intellectual Property"** means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and protocols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.

2.8 **"Parties"** means the Society and Client together.

2.9 **"Party"** means the Society or the Client.

2.10 **"Register"** means the public electronic register of ships updated regularly by the Society.

2.11 **"Rules"** means the Society's classification rules and other documents. The Society's Rules take into account at the date of their preparation the state of currently available and proven technical minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.

2.12 **"Services"** means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: ship and company safety management certification, ship and port security certification, maritime labour certification, training activities, all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board. The Services are carried out by the Society according to the applicable referential and to the Bureau Veritas' Code of Ethics. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.

2.13 **"Society"** means the classification society **'Bureau Veritas Marine & Offshore SAS'**, a company organized and existing under the laws of France, registered in Nanterre under number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.

2.14 **"Unit"** means any ship or vessel or offshore unit or structure of any type or part of it or system whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

3. SCOPE AND PERFORMANCE

3.1 Subject to the Services requested and always by reference to the Rules, the Society shall:

- review the construction arrangements of the Unit as shown on the documents provided by the Client;
- conduct the Unit surveys at the place of the Unit construction;
- class the Unit and enter the Unit's class in the Society's Register;
- survey the Unit periodically in service to note whether the requirements for the maintenance of class are met.

The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.

3.2 The Society will not:

- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
- engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

4.1 The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit for surveys; and (iii) inform the Society in due time of any circumstances that may affect the given appraisement of the Unit or cause to modify the scope of the Services.

4.2 Certificates are only valid if issued by the Society.

4.3 The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.

4.4 The Society may at times and at its sole discretion give an opinion on a design or any technical element that would 'in principle' be acceptable to the Society. This opinion shall not presume on the final issuance of any Certificate or on its content in the event of the actual issuance of a Certificate. This opinion shall only be an appraisal made by the Society which shall not be held liable for it.

5. ACCESS AND SAFETY

5.1 The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawing, etc. required for the performance of the Services must be made available in due time.

5.2 The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

6.1 The provision of the Services by the Society, whether complete or not, involve, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.

6.2 Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interests equal to twelve (12) months LIBOR plus two (2) per cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold Certificates and other documents and/or to suspend or revoke the validity of Certificates.

6.3 In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to solve the dispute.

7. LIABILITY

7.1 The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:

- Indirect or consequential loss;
- Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.

The Client shall defend, release, save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.

7.2 Except in case of wilful misconduct of the Society, death or bodily injury caused by the Society's negligence and any other liability that could not be, by law, limited, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cents (150%) of the price paid by the Client to the Society for the Services having caused the damage. This limit applies to any liability of whatsoever nature and howsoever arising, including fault by the Society, breach of contract, breach of warranty, tort, strict liability, breach of statute.

7.3 All claims shall be presented to the Society in writing within three (3) months of the completion of Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

8.1 The Client shall defend, release, save, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services (including for damages arising out of or in connection with opinions delivered according to clause 4.4 above) except for those claims caused solely and completely by the gross negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

9.1 The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.

9.2 In such a case, the Classification granted to the concerned Unit and the previously issued Certificates shall remain valid until the date of effect of the termination notice issued, subject to compliance with clause 4.1 and 6 above.

9.3 In the event where, in the reasonable opinion of the Society, the Client is in breach, or is suspected to be in breach of clause 16 of the Conditions, the Society shall have the right to terminate the Services (and the relevant contracts associated) with immediate effect.

10. FORCE MAJEURE

10.1 Neither Party shall be responsible or liable for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.

10.2 For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts.

11. CONFIDENTIALITY

11.1 The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, are treated as confidential except where the information:

- is properly and lawfully in the possession of the Society;
- is already in possession of the public or has entered the public domain, otherwise than through a breach of this obligation;
- is acquired or received independently from a third party that has the right to disseminate such information;
- is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure.

11.2 The Parties shall use the confidential information exclusively within the framework of their activity underlying these Conditions.

11.3 Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.

11.4 Without prejudice to sub-clause 11.1, the Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

12.1 Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.

12.2 The Intellectual Property developed by the Society for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain the exclusive property of the Society.

13. ASSIGNMENT

13.1 The contract resulting from to these Conditions cannot be assigned or transferred by any means by a Party to any third party without the prior written consent of the other Party.

13.2 The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

14.1 Invalidity of one or more provisions does not affect the remaining provisions.

14.2 Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.

14.3 In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

15.1 These Conditions shall be construed and governed by the laws of England and Wales.

15.2 The Parties shall make every effort to settle any dispute amicably and in good faith by way of negotiation within thirty (30) days from the date of receipt by either one of the Parties of a written notice of such a dispute.

15.3 Failing that, the dispute shall finally be settled under the Rules of Arbitration of the Maritime Arbitration Chamber of Paris ("CAMP"), which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be Paris (France). The Parties agree to keep the arbitration proceedings confidential.

16. PROFESSIONAL ETHICS

16.1 Each Party shall conduct all activities in compliance with all laws, statutes, rules, economic and trade sanctions (including but not limited to US sanctions and EU sanctions) and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption, copyright and trademark protection, personal data protection (https://personaldataprotection.bureauveritas.com/privacypolicy).

Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official, or candidate.

16.2 In addition, the Client shall act consistently with the Bureau Veritas' Code of Ethics.
https://group.bureauveritas.com/group/corporate-social-responsibility

GUIDANCE NOTE NI 653

NI 653
Risk-Based Structural Integrity Management for Topside Structures

October 2018

SECTION 1 GENERAL

1 General

1.1 Context

1.1.1 Current industrial practice for the inspection of topsides structures is based on API-RP-2SIM requirement that inspection of topsides structure be performed annually by visual examination. However, the final report of the Joint Industry Project (JIP) on the Structural Integrity Management (SIM) of topsides structures acknowledged that even if the annual visual inspection allows a high proportion of typical degradations to be detected, it may fail in detecting those that lead to a significant percentage of the reported failures (MSL, 2004). It proposed therefore a risk-based approach as an alternative to improve topsides inspection regimes. This leads to more frequent and detailed inspection of high-risk structures increasing the likelihood of detecting early enough critical defect.

Following the release of the API-RP-2SIM which addresses the issue of Risk-Based Inspection (RBI) especially for the underwater structure of fixed offshore platforms, the development of guidance for the RBI of other offshore structures, especially topsides structures is being considered. In this vein, the International Organization for Standardization (ISO) has developed a specific standard for the SIM of offshore structures (ISO/DIS 19901-9) including topsides structures in which guidance for performing RBI is provided.

1.2 Scope of the document

1.2.1 This Guidance Note is intended to sets out the main recommendations and requirements of the ISO/DIS 19901-9 for implementing a risk-based structural integrity management for offshore topsides structures. It includes, also, relevant guidance from other international standards and from technical reports and research papers.

This Guidance Note presents also a generic RBI method of the Society for topsides structures. This method is based on ISO guidance and is to be used as part of the SIM to develop an inspection strategy.

1.3 Overview of ISO guidance

1.3.1 ISO/DIS 19901-9 includes guidance for risk-based approach to SIM of offshore topsides structures. Although most of it is dedicated to fixed steel offshore structures (e.g. jackets, towers, etc), it covers also all topsides and structures above sea level, 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.

1.3.2 The ISO recommends that risk-based approach for developing SIM strategy be applied to safety-critical structural items. For those ones a performance standard should be established, that serves as a basis for appraising their risk level and for defining the SIM strategy. A so-called Major Accident Approach is recommended for selecting critical structural items and typical examples of critical structural items are provided in the appendix of the standard. However, no guideline is provided on how to set up their performance standards.

General guidelines for risk categorization in terms of the exposure category and the likelihood of failure are provided for the whole platform. However, the basic principles are applicable to topsides structures too.

Indicative risk-based inspection intervals are proposed for the inspection planning of topsides critical structural items. The type of inspection, i.e. general visual inspection (GVI), close visual inspection (CVI) and/or none-destructive examination (NDE), to be used with those intervals should be selected based on the type of expected deterioration/degradation and the present known condition of the topsides critical structural item under consideration.

More detailed guidance is provided on the inspection program, including inspection specifications and requirements for using most of the inspection methods.

1.3.3 The ISO points out the necessity to take into account the structural integrity interfaces in planning for the inspections.

1.3.4 ISO recommends also that a maintenance strategy be implemented for those structures where significant degradation mode are possible. The maintenance strategy should include coating maintenance and grating replacement and may be defined on a risk analysis basis.

1.4 Overview of the Society's method

1.4.1 The Society has developed a generic risk-based inspection planning method to be used as part of the SIM of topsides structures.

In particular, the method:

- adopts the general framework recommended by the ISO for developing inspection plan
- provides guidelines in selecting the critical structures on which RBI should be applied
- defines the minimum structural performance required from the selected structures
- develops a risk assessment method, using a rule-based scoring approach for the likelihood of failure and a categorization of the consequence of failure in terms of life-safety, environment and financial loss
- sets up a calibration process for the likelihood assessment that can include an owner or operator specific risk tolerance criteria

- develops risk-based inspection strategies in conformance to ISO recommendations.

The method reflects current industrial best practice and puts emphasize on the understanding of the risk.

1.5 Organization of the document

1.5.1 The existing guidelines for performing SIM for topsides structures are set out in Sec 2.

- the requirements of the main standards, which address SIM of topsides structures, are summarized
- the general requirements for SIM of topsides structures are pointed out
- an emphasize is put on presenting requirements and recommendation for developing risk-based inspection planning.

A generic risk-based inspection planning method developed by the Society as part of the SIM of topsides structures is presented in Sec 3.

Typical examples of structural data required for the SIM process are provided in App 1.

Typical examples topsides critical structures on which RBI should be applied. are provided in App 2.

Existing guidelines for the assessment of the condition of protective coating systems are set out in App 3.

2 References, definitions and acronyms

2.1 References

2.1.1 Standards

API-RP-580, Risk-Based Inspection (2nd ed.). Washington: API Publishing Services, 2009.

API-RP-2SIM, Structural Integrity Management of Fixed Offshore Structures (1st ed.). Washington: API Publishing Services, 2014.

ASTM D5065, Standard Guide for Assessing the Condition of Aged Coatings on Steel Surfaces, 2013.

ASTM D610, Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces, 2012.

ASTM D4214, Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films, 2015.

ASTM D660, Standard Test Method for Evaluating Degree of Checking of Exterior Paints, 2011.

ASTM D714. Standard Test Method for Evaluating Degree of Blistering of Paints, 2009.

ISO 19901-3, Petroleum and natural gas industries – Specific requirements for offshore structures – Part 3: Topsides structure, 2014.

ISO/DIS-19901-9, Petroleum and natural gas industries – Specific requirements for offshore structures – Part 9: Structural integrity management, 2017.

ISO 19902, Petroleum and natural gas industries – Fixed steel offshore structures, 2007.

ISO 4628, Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance

- Part 1: General introduction and designation system, 2016.
- Part 2: Assessment of degree of blistering, 2016.
- Part 3: Assessment of degree of rusting, 2016.
- Part 4: Assessment of degree of cracking, 2016.
- Part 5: Assessment of degree of flaking, 2016.
- Part 6: Assessment of degree of chalking by tape method, 2011.
- Part 7: Assessment of degree of chalking by velvet method, 2016.
- Part 8: Assessment of degree of delamination and corrosion around a scribe, 2013.
- Part 10: Assessment of degree of filiform corrosion, 2016.

NORSOK N-005, Condition Monitoring of Loadbearing Structures, 2017.

NORSOK N-006, Assessment of structural integrity for existing offshore load-bearing structures, 2015.

SSPC – Visual Standard 2, Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces, 2000.

2.1.2 Other guidance

HSE, Prevention of Fire & Explosion and Emergency Response on Offshore Installations, Approved Code of Practice and Guidance, 2016.

HSE, Structural integrity management framework for fixed jacket structures, Research Report RR684, 2009.

HSE, Advice on acceptance criteria for damaged Passive Fire Protection (PFP) Coatings, Offshore Information Sheet No. 12/2007, 2007.

Step Change in Safety – Assurance and Verification Practitioner's Guide, 2015.

2.1.3 JIP reports

MSL Engineering, Ltd. – Guidelines of the Definition and Reporting of Significant Damage to Fixed Steel Offshore Platforms, JIP Report, 2003.

MSL Engineering, Ltd. – Development of Integrity Methodologies for the Topsides of Offshore Production Facilities, JIP Report, 2004.

2.1.4 Conferences papers

Axelsen S. B., Knudsen O. O. and Johnsen R., Protective Coatings Offshore: Introducing A Risk Based Maintenance Management System, NACE CORROSION conference & expo, USA, 2009.

Sharp J.V., Stacey A, Birkinshaw B., Application of Performance Standards to Offshore Structural Components, OMAE Conference, 1999.

Sharp, J. V., Ersdal, G. and Galbraith, D., Development of key performance indicators for offshore structural integrity, OMAE Conference, Portugal, 2008.

Versowsky, P. E., Rationalization and Optimization of Coatings Maintenance Programs for Corrosion Management on Offshore Platforms. Workshop on Coatings for Corrosion

Protection: Offshore Oil and Gas Operation Facilities, Marine Pipeline and Ship Structures and Port Facilities, National Institute of Standards and Technology, Biloxi, Mississipi, 2004.

2.2 Terms and definitions

2.2.1 Anomaly

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

2.2.2 Assessment

Detailed qualitative or quantitative determination of the structural component or system strength.

2.2.3 Consequence

Effects of an abnormal event, such as extreme metocean event, seismic event, ice or accidental event, on personnel, the environment, or the property.

2.2.4 Defect

Imperfection, fault, or flaw in a structural component.

2.2.5 Degradation / deterioration

Reduction in the ability of a component to provide its intended purpose.

2.2.6 Evaluation

Review of condition of the structure compared to that when it was last assessed and other parameters that affect the integrity and risk levels to confirm or otherwise that the existing structural assessments still apply.

2.2.7 Exposure level

The classification used to categorize the platform consequence of failure based on consideration of life safety, environmental pollution and business disruption.

Three exposure levels are used and they are defined as follows:

- exposure level L-1 refers to manned-non-evacuated platforms or high consequence of failure platforms in terms of environmental pollution or financial loss
- exposure level L-2 refers to manned-evacuated platforms or medium consequence of failure platforms
- exposure level L-3 refers to unmanned platforms or low consequence of failure platforms.

2.2.8 Failure

Insufficient strength or inadequate performance of a structure or system, preventing it from fulfilling its intended performance requirements.

2.2.9 Fitness-for-service

Engineering evaluations performed to demonstrate the structural integrity of structural component that could contain a flaw or damage or that could be operating under specific conditions that could produce a failure.

2.2.10 In-process inspection

Application of various tests on the structures or equipment at each stage of the fabrication, the construction, the commissioning, the transportation and the installation processes to ensure that they are installed in conformance with project specifications and/or industry standards.

2.2.11 In-service inspection

All inspection activities associated with a structure once it has been installed but before it is de-commissioned.

2.2.12 Inspection

Visit to the platform and the associated survey activities for purposes of collecting data required in evaluating its structural integrity for continued operation.

2.2.13 Inspection plan

A plan for the in-service inspection of a structure including the scheduled dates and the expected scope of the inspections.

2.2.14 Inspection program

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

2.2.15 Maintenance

Upkeep of the required condition of the structure by proactive intervention e.g. painting, repair, replacement, greasing...

2.2.16 Mitigation

Limitation of negative consequence or reduction in likelihood of particular event or condition.

2.2.17 Operator

The person, firm, corporation, or other organization employed by the owners to conduct operations.

2.2.18 Owner

Party who owns the physical infrastructure and is responsible for maintaining structural integrity.

2.2.19 Performance level

Criteria for which an existing platform should achieve to confirm fitness-for-service.

2.2.20 Performance standard

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

2.2.21 Policy

Intention and direction of the owner with respect to the SIM related processes and activities.

2.2.22 Practice

Formal document that establishes the technical criteria, methods and processes.

2.2.23 Primary, secondary and tertiary structural components/members

Primary structural components provide stiffness and strength to the overall structure e.g. legs, all truss members, plate girders, horizontal bracing.

Secondary structural components are essential to the local integrity of the structure where failure of these components will not affect the overall integrity e.g. deck plate, deck beam, main escape walkways and stairs, crane pedestal.

Tertiary structural components are ancillary structural components including minor structural members and attachments e.g. handrails, gratings, supports connections, anti buckling stiffeners of deck plate.

2.2.24 Procedure

Written directive, usually arranged chronologically, which provides details and steps required to perform a given activity.

2.2.25 Redundancy

Availability of alternate load paths in a structure following the failure of one or more structural components.

2.2.26 Residual strength

Ultimate strength of an offshore structure in a damaged condition.

2.2.27 Review

Process used to determine how the SIM processes can be improved on the basis of in house and external experience and industry best practice.

2.2.28 Risk-based inspection

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.

2.2.29 Robustness

Ability of a structure to tolerate damage without failure.

2.2.30 Service life

Time period associated with the structure's anticipated end of field life or decommissioning date.

2.2.31 Strategy

Process for delivering the structural integrity consistent with the SIM policy.

2.2.32 Structural analysis

Calculation to predict the behavior of the structure usually relative to specified code requirements.

2.2.33 Structural assessment

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

2.2.34 Structural integrity

Ability of a structure to perform its required function over a defined time period whilst protecting health, safety and the environment.

2.2.35 Structural integrity management

Means of demonstrating that the people, systems, processes and resources that deliver integrity are in place, in use and will perform when required of the whole lifecycle of the structure.

2.2.36 Supporting structure

Structure supporting the topsides such as fixed steel jacket structure, gravity based structure, hull of floating unit.

2.2.37 Survey

Specific visual or non-destructive examination of one or more platform's components.

2.2.38 Topsides

Structures and equipment placed on a supporting structure (fixed or floating) to provide process onboard.

Note 1: For a ship-shaped floating structure, the deck is not part of the topsides.

Note 2: For a jack-up, the hull is not part of the topsides.

Note 3: A separate fabricated deck or module support frame is part of the topsides.

2.2.39 Walk-down

A methodical, on-site, visual evaluations of existing structures and equipment as installed.

2.3 Acronyms

2.3.1

API : American Petroleum Institute

ASTM : American Society for Testing Material

CoF : Consequence of Failure

CS : Critical Structure

CVI : Close Visual Inspection

DLM : Design Level Method

GVI : General Visual Inspection

HSE : Health and Safety Executive

ISO : International Organization for Standardization

JIP : Joint Industrial Project

LoF : Likelihood of Failure

MAH : Major Accident Hazard

MOC : Management Of Change

NDE : Non Destructive Examination

NDT : Non Destructive Testing

NORSOK: Norwegian standards (NOrsk SOkkels Konkurranseposisjon)

PFEER : Prevention of Fire and Explosion, and Emergency Response

PFP : Passive Fire Protection

RBI : Risk-Based Inspection

SIM : Structural Integrity Management

SSPC : The Society for Protective Coatings.

SECTION 2 REVIEW OF EXISTING GUIDELINES

1 General

1.1 Benefits of risk-based SIM

1.1.1 Risk-based SIM strategy is likely to lead to a significant improvement of the inspection planning in comparison with the prescriptive SIM strategy.

1.1.2 Potential benefits of risk-based SIM include:

- Prioritisation of inspection resources – structures and components can be prioritized on a risk basis.
- Increased knowledge of assets – SIM requires evaluation of available data and assessments, which provides knowledge on the structure's condition, strength and fatigue resistance.
- More effective management of change (MOC) – records can be reviewed and maintained, thereby allowing transfer of knowledge and learning for the owner and improving decisions.
- Planned maintenance in lieu of on-the-spot repairs or modifications.
- Increased knowledge of a structure's condition, strength and fatigue resistance may allow increased time to engineer a repair; review of assessment can result in no repair.

2 Overview of standards guidelines

2.1 General

2.1.1 Three standards, namely the API, the ISO and the NORSOK provide the most coverage of SIM of topsides structures. However, only ISO provides guidelines for risk-based SIM of topsides structures.

2.2 API

2.2.1 API does not address risk-based SIM for topsides structures. It provides guidance for the in-service inspection of the above water structures of fixed platforms. It requires this inspection to be performed on an annual basis using mainly GVI and provides detailed scope of work.

2.2.2 The scope of work of the inspection includes:

- A visual survey of all structural members in the splash zone and above water, concentrating on the condition of the more critical areas such as deck legs, girders, trusses, members, joints, leg/pile welds, etc
- A coating survey to assess the effectiveness and condition of the various protective coating systems (e.g. corrosion protection coatings and PFP) on the topsides
- Appurtenance and personnel safety devices survey, including 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 temporary refuge
- Deck elevation survey
- Supplemental survey including NDT, material sampling, wall thickness measurements, paint thickness measurement, etc, in order to characterize damage if required.

2.3 ISO

2.3.1 ISO guidelines for SIM cover the above water structures of fixed platforms and topsides structures on floating facilities and permanently located jack-ups, regardless of where those structures are located and how they were designed, fabricated and installed.

2.3.2 Guidance already exists in the ISO 19901-3, which is the ISO standard for the design of the topsides structures. It addresses in-service inspections only, including:

- inspection interval defined as those described in the ISO 19902
- default inspection work scope
- particular consideration to account for topside SIM, especially the inspection of safety critical supports for equipment e.g. safety critical communications, electrical and firewater systems, etc.

2.3.3 The ISO/DIS 19901-9, the stand-alone ISO standard for SIM, provides most and up-to-date guidance and addresses in particular the risk-based SIM of topsides structures. It repeats the API inspection requirements, but uses them as the default prescriptive inspection scope of work.

2.3.4 ISO/DIS 19901-9 recommends that risk-based SIM strategy be developed for the critical structures (CS) which are parts of the platform structure, the failure of which will cause specific life-safety, environmental pollution or financial consequences. The provided recommendations and requirements include:

- factors to account for the assessment of likelihood of failure
- indicative risk-based inspection interval for the topsides CS
- detail inspection scope of work
- pre-selected inspection locations.

2.3.5 ISO/DIS 19901-9 addresses, in addition, the issue of structural integrity interfaces. This is particularly relevant when dealing with the SIM of topsides as the inspection of the latter interfaces with many integrity management activities.

2.4 NORSOK

2.4.1 The standard N-005 (NORSOK, 2017) on the condition monitoring of loadbearing structures is the relevant NORSOK standard for the SIM of topsides structures. It covers all the offshore structures including topsides structures and above water structures of fixed offshore units. It addresses also all the SIM activities including in-service inspection and structural condition assessment. As set out in the title it is suitable for loadbearing structures. However, risk-based approach is not explicitly addressed in this standard, but rather in another NORSOK standard, the standard N-006, which provides especially guidance on probabilistic inspection planning methods for fatigue cracks monitoring.

The main requirements of the standard N-005 on SIM and the guidelines of the standard N-006 on probabilistic inspection planning methods are summarized in the sequel.

2.4.2 N-005

The requirements of the standard N-005 on SIM of topsides structures and above water structures are given by general statements. They are summarized below.

a) The condition monitoring (i.e. inspection) should be focused on the identified safety-critical structural components

b) No specific inspection intervals are recommended for the periodic inspections of interest in this document, and no mean is suggested for defining those intervals.

c) The qualifications required for the personnel undertaking NDE are specified

d) The parameters the negative effects of which cause structural damage on topsides and splash zone are set out, namely:
   - For topsides (i.e. atmospheric zone)
     - structural design errors
     - air humidity
     - condensation
     - sea spray
     - temperature variations
     - mechanical loads
     - wave loads
     - other environmental conditions
     - static and dynamic loads
     - altered operational conditions
     - in particular, area with restricted accessibility should be taken into account, but no indication on how to proceed is given.
   - For the splash zone, in addition to those listed for the atmospheric zone:
     - the alternating effects of wet and dry surface
     - denting of the structure
     - missing or deformed structural members
     - pitting
     - marine growth.

e) The standard provides in appendix a description of the widely used inspection methods, safety procedures in conducting in-service inspection and specific requirement applicable per type of offshore facilities e.g. jacket structures, column stabilized unit, ship-shaped units and concrete structures. However, no specific requirement is provided for topsides structures.

2.4.3 N-006

The standard N-006 include a section providing basis for using probabilistic methods for planning of in-service inspection for fatigue cracks.

This approach requires:

- S-N data
- a suitable fracture mechanic model
- information about probability of detecting cracks
- acceptance criteria

The inspection interval is derived from the computed annual probability of fatigue failure.

A first step to use probabilistic analysis for planning in-service inspection for fatigue cracks is to calculate accumulated probability of failure based on S-N data. This is used to determine the time to first inspection.

Then a fracture mechanics approach involving integration of crack growth model and the probability of crack detection is used to define the next inspection intervals. To achieve reliable results it is recommended to perform a calibration of the fracture mechanics fatigue approach to that of fatigue test data (S-N data).

The acceptance criteria are established with respect to the consequence of fatigue failure and they are derived from the design fatigue factor required for the joints under consideration.

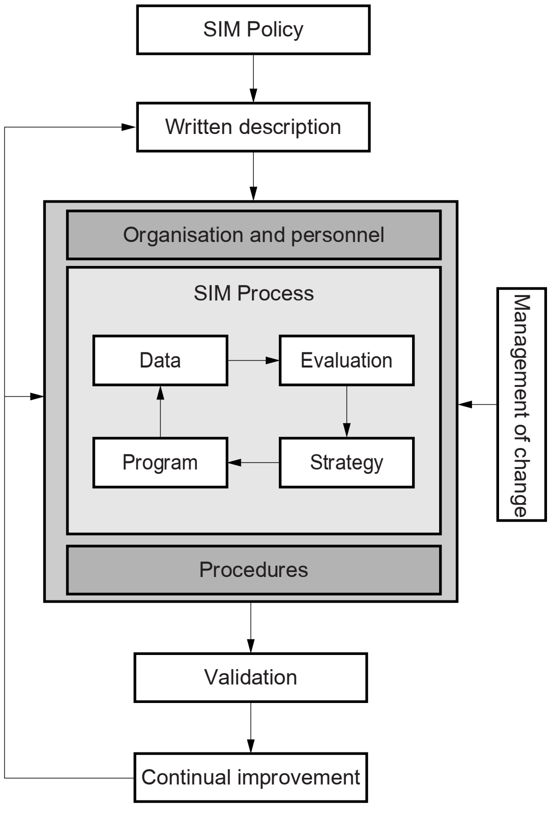
3 General requirements

3.1 Management framework

3.1.1 The management framework refers to the integrated systems, work processes and documentation, which are used together with the SIM process to deliver structural integrity, including (see Fig 1):

- company policy, which sets out the intention and direction of the owner with respect to SIM
- written description, which documents the processes and procedures adopted by the owner 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, including all the activities to be set up for demonstrating fit-for-service assets
- procedures, which are followed for implementation of the required activities
- MOC, which is used to identify and monitor changes
- validation, which is used to measure and verify performance against a set of defined metrics
- continual improvement, which reviews the process periodically and implement required changes.

Figure 1 : Management framework.



3.1.2 The ISO requires that owner establishes and maintains a management framework that provides evidence to the corporate and regulatory stakeholders that the owner has a commitment to a sustainable life-cycle approach to demonstrate structural fitness-for-service.

3.2 Risk tolerance

3.2.1 The ISO requires that the owner establishes the tolerable risk, either qualitatively or quantitatively, for life-safety risk, environmental pollution risk and financial risk, in order to adopt a risk-based approach.

3.2.2 Minimum standard performance level are provided in the form of return period metocean criteria that the platform as a whole must withstand with respect to the expected consequence of collapse failure.

3.2.3 The owner tolerable risk must be more stringent than the tolerable risk limit to life-safety and to environment pollution provided by the minimum standard performance level.

This minimum standard performance level is provided at a high level in the form of return period metocean criteria that the platform as a whole must withstand with respect to the expected consequence of collapse failure Tab 1).

3.3 Data requirements

3.3.1 The accuracy of the risk assessment is strongly dependent on the amount and quality of the available data.

3.3.2 Data must include information from the original design of the structure, fabrication, construction and installation data, inspections data, effects of damage and deterioration, structural analyses, overloading, and changes in loading and/or use. In addition, data should include technology development projects or in-service experience of similar structures within industry.

Typical topside structural data are set out in App 1.

3.3.3 The data should be included and maintained in a data management system.

3.3.4 If data is missing or is inaccurate, inspection should be conducted to provide the necessary information, otherwise conservative assumption, made by a qualified engineer, should be used for the risk assessment.

Table 1 : Minimum fitness-for-service performance level

Life safety				Environmental pollution **(3)**		
Consequence	Return Period **(1)**	Comments		Consequence	Return Period **(1)**	Comments **(5)**
Manned	2500 years **(2)**	Possible fatalities		High	1000 years	Possible environmental pollution
Unmanned	N/A	No fatalities		Low	100 years **(4)**	Limited environmental pollution

(1) Return period used to set the fitness-for-service performance level is the return period of the metocean event defined with the appropriate statistical distribution.

(2) If life-safety mitigation procedures are in-place to unman the platform prior to the forecast of a predetermined metocean event (e.g. hurricane or typhoon) the minimum performance level may be based on a reduced population storm (e.g. sudden hurricane for U.S. Gulf of Mexico).
If life-safety mitigation procedures are in-place to unman prior to the forecast of a predetermined sea state the minimum performance level may be based on the predetermined sea state.
If life-safety mitigation procedures are not in-place then the metocean hazard performance level shall be based on the full population storm.

(3) Financial loss performance level should be established by the owner in conjunction with possible requirements from the national regulator.

(4) Performance level is set in relation to mitigating the possible effects on life-safety and the environment in the event of platform collapse. Use of the low environmental consequence performance level can result in placing an economic burden on the owner.

(5) Extent of environmental pollution should be based on regulatory stakeholders interpretations.

3.4 Structural integrity interface

3.4.1 The ISO requires that the topsides SIM addresses the interfaces with other discipline-specific integrity programs and the SIM of third-party packages included on the topsides.

3.4.2 The structural integrity interfaces to be addressed can be divided into:

- The interface between the topsides structures and other elements managed by a different inspection regime e.g. the connections between the support structure and the equipment or topsides structures and the appurtenances
- The interface between the underwater inspection activities and the above water inspection activities in which the topsides structures are included

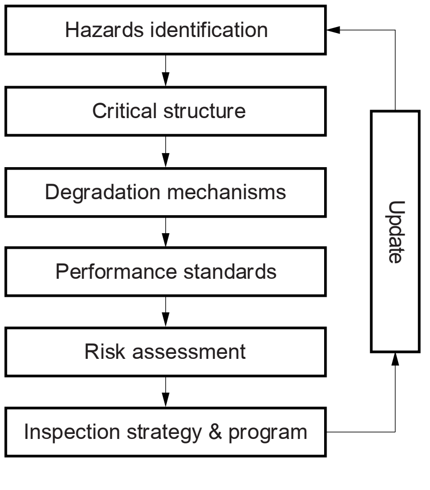
  The SIM of a topsides structure shall be consistent with the SIM process principles used for the supporting structure
- The interface between the topsides structure general inspection regime and some structures under specific inspection requirements such as cranes, helideck, personnel safety devices.

3.5 Inspection planning process

3.5.1 Developing a risk-based inspection strategy for topsides structures includes the following steps (see Fig 2):

- identification of the CS
- setting of performance standards for the CS
- risk assessment, including consequence and likelihood of failure evaluation, for each CS
- inspection intervals and technique for each CS
- loop back to refine evaluation as inspection data becomes available.

Figure 2 : Inspection planning process.



4 Critical structures

4.1 General

4.1.1 The CS may be divided into system, sub-system or component level as required.

4.1.2 The current ISO standard for the design of topsides structures (ISO 19901-3) requires that CS be identified before production starts (i.e. in the fabrication yard or shortly after installation) by a walk-down study. The CS are usually recorded in a risk register, when such document is available. However, identification and categorization of CS may not have been undertaken for an ageing platform.

4.1.3 Guidelines exist for the identification of CS. They are especially provided by the ISO (ISO/DIS-19901-9) and JIP on SIM of topsides (MSL, 2004).

Guidelines provided by the ISO allow the identification and the categorization of the CS to be undertaken based on their consequences of failure using a major hazard (MAH) approach. Examples of typical CS selected by such approach are also provided.

The guidelines of the JIP on SIM topsides include, in addition to the consequence of failure, consideration of the failure susceptibility assessed from historical inspection data of the platforms in the Gulf of Mexico.

4.2 ISO guidelines

4.2.1 According to ISO, the CS typically include the structural barriers that are used to prevent an event from causing a major incident and/or the structural barriers used to provide mitigation and de-escalation in the event of an incident.

4.2.2 ISO does not provide detailed guidance on the identification and the categorization of CS in the core text of the ISO/DIS-19901-9, but it sets out in appendix examples of CS selected based on a so-called major accident hazard (MAH) approach.

A MAH is defined as an event involving major damage to the structure of the installation with the potential to cause fatalities or an incident which results, or is likely to result, in significant adverse effects on the environment.

The examples of typical CS provided by the ISO are repeated in App 2 for information.

4.3 Guidelines from the JIP on SIM Topsides

4.3.1 This JIP on SIM Topsides has been carried out with the aim of developing a SIM method for the topsides including structures, plant and piping (MSL, 2004). As part of the work done, a criticality ranking of the topsides structures was undertaken in order to identify the safety-critical structural items.

The method used for this criticality ranking involved:

- a review of historical inspection data together with some engineering assessment to define likelihood of failure of the structural items
- a classification of the consequence of this failure
- a criticality ranking based on the likelihood and the consequence categorization.

4.3.2 The safety-critical structural items were identified as those with higher criticality rank:

- For all platforms
  - Deck plating / grating
  - Helideck and safety nets
  - Walkway grating and associated supporting structure
  - Handrails including posts
  - Stair treads and stringers
  - Swing ropes connections
  - Access platforms and attachment points
  - Risers supports/protectors.
- For platforms of exposure levels L-1 and L-2 only
  - Secondary and tertiary structural framing
  - Boat landings and fenders
  - Pipework supports
  - Conductors supports
  - Service caissons supports.

4.4 General guidelines

4.4.1 The identification of the CS should take into account both the potential for failure and the severity of the corresponding consequence. Therefore, it should be based on considerations such as:

- the existence of structural components that are subject to high loading
- the existence of structural components that are subject to cyclic loading likely to lead to fatigue
- the history and future likelihood of corrosion and other defects
- the availability of alternative load paths where a structural component can be defective (i.e. robustness and redundancy level)
- criticality of the structure to safety, production and the environment

4.4.2 In particular, structures protected by a passive or an active fire protection system are part of the CS.

5 Performance Standards

5.1 General

5.1.1 Definition

A performance standard is defined by the ISO, which repeats the reference definition provided by the Approved code of practice to the PFEER (HSE, 1995), as a statement, which can be expressed in qualitative or quantitative terms, of the performance required from a system, item of equipment, person or procedure and which is used as the basis for managing the hazard through the life-cycle of the installation.

The ISO requires that performance standard be defined for each of the identified CS, which will serve as a basis in defining the SIM strategy.

Thus, concerning CS, their performance standards are given by the performance criteria they must achieve in order to fulfill their role in hazard management.

Specific performance standards are usually set for each of the phases of the life-cycle, from the phases of design, construction, installation and operation (including inspection, repair, and modification), to the phases of life extension and decommissioning. For risk-based inspection planning, only the performance standards in the operational phase are of interest. In particular, the required performance standards will serve has a basis to assess the likelihood of structural failure and to develop the risk-based inspection strategy.

Note 1: Specific performance standards are also established for the inspection and repair procedures, however, those aspects are not addressed in this document.

5.1.2 General guidelines for setting effective performance standards

General guidelines for setting effective performance standards are provided by the PFEER (HSE, 1995). A suitable definition for a performance standard should satisfy the following conditions (Step Change in Safety, 2015):

- Scope and functionality of the system must be described/defined
- Criteria must be specified for each safety critical component and these criteria should have a clearly defined (technical) basis
- Parameters must be measurable / auditable with defined acceptance criteria
- Measured parameters must provide evidence of the ability of the component/system to meet its minimum requirements and hence to prevent or limit the effect of a Major Accident

Poorly defined performance standard may be ineffective or even ignored, increasing the possibility of a Major Accident, especially, if it is difficult to measure, if important aspects/issues are missing, or if it is difficult to understand.

5.1.3 FARSI model for Performance Standards

The PFEER states that performance standards should be defined with respect to functionality, survivability, reliability and availability requirements. The interaction with other elements, the performance of which affects the performance of the item under consideration, should also be taken into account. Together, those types of requirement form the so-called FARSI (Functionality, Availability, Reliability, Survivability and Interaction) model of performance standard, and allow a comprehensive list of parameters relevant for the performance to be identified and acceptance criteria to be decided for them in order to define in detail the performance requirement of the CS under consideration.

The FARSI model shows the key requirements that are usually included in a performance standard.

a) Functionality requirement defines what the structure is required to do e.g. to support equipment, to connect pipework to the structure.
b) Availability or Reliability requirement defines the ability of the structure to fulfill its role whenever it is required to do so.
c) Survivability requirement defines how the structure will perform after an extreme event e.g. fire, explosion, dropped object, extreme weather, etc.
d) Interaction requirement defines the other safety critical elements which are required to function in order for the structure in question to function effectively.

For the CS, specific criteria can be established in the operational phase for the functionality requirement. A measurable functionality criterion for a CS may be expressed in terms of the maximum allowable degradation that can be tolerated. This may be derived from international standard, duty holder's degradation classification, industry guideline or other best practice. It is likely that those criteria be less severe than the criteria used in the original design.

The other types of requirement are usually defined at the design phase, but they should be measured during the operational phase to confirm compliance. For example, compliance with the minimum acceptable reliability and the robustness required to satisfy survivability criteria can be checked, if required, in the operational phase using a structural assessment.

5.2 Structural performance standard

5.2.1 General

No generic requirement exists for setting a structural performance standard in the operational phase for topside structures. In practice, those are given in the form of high-level statements regarding the required level of structural integrity without specific requirements with respects to potential hazards (HSE, 2009). Little work has been undertaken so far on the issue of performance standards for offshore structures in the operational phase. The paper (Sharp, et al., 1999) shows how to better define performance standards for structural components. The paper (Sharp, et al., 2008) described the background to developing Key Performance Indicators (KPIs) for offshore structures regarding the required performance standards. However, these have not been widely applied in the industry.

In practice, current design criteria in codes and standards can provide a basis for setting performance standards for topsides structures. However, the performance standards required for an existing structure should be less restrictive than those required at its design stage.

The structural performance standard should specify:

- acceptance criteria for protective coating system, if applicable
- acceptance criteria for the condition of the structure

It should provide also means to assess the condition of the structure in-service, especially the condition of a degraded structure.

5.2.2 Acceptance criteria for the condition of protective coating system

The main objective of coatings is to constitute a barrier between the metal substrate and its aggressive environment, by providing:

- resistance from mechanical, chemical and biological degradation
- dielectric insulation
- thermal insulation.

There are no standard acceptance criteria on the extent of coating degradation in-service. Most of the standards resources available include acceptance criteria on the condition of the initial coating to be used for in-process inspection. However, those acceptance criteria are so restrictive to ensure a quasi-perfect sate of the initial coating that they are not suitable for in-service inspection for which some damage may be tolerated; moreover, they involve some advanced testing techniques that are rarely used for in-service inspection which usually uses visual examination.

It is reasonable to consider that the minimum performance required from coatings is the achievement of its main function. Obviously, a coating system will no longer achieve its function when the degradation, it is subjected to, leads to the metal substrate being exposed to its aggressive environment. The term “exposed” has a broader meaning here by covering situation where coating is partly or totally removed or when the insulation properties of the coatings are altered.

5.2.3 Acceptance criteria for the condition of the structure

The main function of a structure is to support and transmit the loads occurring. Therefore, its strength must be larger than those expected loads.

Acceptance criteria on the require strength of a degraded structure along with assessment methods are provided by ISO. The criteria based on the ultimate strength of a structure which lead to the most accurate and less conservative assessment are widely applied to jacket underwater structure but no such application exists for topside structures. Therefore, criteria based on Design Level Method (DLM) are more suitable to topside structures. However, those criteria are component based, meaning that the most loaded structural component drives the assessment. Moreover, the DLM criteria usually includes safety factors. Thus, strictly applying the DLM criteria is too restrictive for in-service assessment for which some level of damage may be tolerated.

Therefore, the acceptance criteria for the condition of a CS will be given by an acceptable number of failed structural components in terms of DLM criteria. Moreover, the safety factors may be removed from the DLM criteria, if this is deemed possible from operational experience, in order to reduce further the conservatism level of those criteria.

5.3 Assessment of the condition of a degraded coating system

5.3.1 General

The condition of degraded coating system can be assessed by the existing standard grading systems.

Details on those grading systems are provided in App 3.

5.3.2 Assessment of the condition of corrosion-protective coating

Standard grading systems for the assessment of the condition of the corrosion protection coatings applied on topsides structures are available from:

- the ISO
- the ASTM
- the SSPC.

Those standards provide pictorial guidelines for the visual assessment of the extent of corrosion on the surface of painted steel. Their rating scales are different but there is an equivalence relationship between them. The grading systems are used to assess the overall condition of the coating. Localized damage on coatings are rather taken into account for the structural condition assessment.

The Minerals Management Service (MMS) of the United States Department of the Interior has also proposed a simplified A, B, C classification of the condition of corrosion protection coatings. An improvement of the MMS grading system has been suggested in the paper by Versowsky (2004), which defined corrosion assessment in terms of coatings deterioration and degree of substrate corrosion.

5.3.3 Assessment of the condition of PFP

The condition of the passive fire protection (PFP) can be assessed based on HSE guidelines. HSE provided advices on acceptance criteria for damaged PFP, based on the results of a Joint Industry Project (JIP) that has examined the performance of cementitious and epoxy intumescent PFP (HSE, 2007).

5.4 Assessment of the condition of a degraded structure

5.4.1 General

For in-service inspections, the condition of a degraded structure is assessed by the extent of degradation of the structure material, including corrosion wastage, fatigue cracks, dent depth, etc. The acceptable limit for extent of degradation of the structure itself is often given by an acceptable size of defect e.g. dents depth, thickness reduction, crack length, etc. No standard rule was found specifying such limit, but in practice, those acceptable limits refer to a proportion given in percentage of a characteristic dimension (e.g. diameter, thickness) of the structural component under consideration. Those limits could be related to a corresponding reduction in structural capacity. However, their corresponding structural capacities are significantly conservative in comparison to the required minimum structural capacity.

5.4.2 Assessment of the residual capacity of a degraded structure

When an accurate assessment of the residual structural strength of a degraded structure is required to directly assess the structural performance against adverse conditions (extreme weather condition, extreme accidental loading or fatigue, whatever is applicable) there are means available to perform the computation. The existing guidelines include:

a) Residual strength:

   Calibrated analytical formula for the residual static strength of a damaged or corroded structural member are provided by the ISO 19902.

b) Remaining fatigue life:

   The ISO like the API allow an analytical procedure in accordance with ISO 19902 or API-RP-2A-WSD to be applied to the structure in its as-is condition.

6 Risk Assessment

6.1 General

6.1.1 Risk assessment should be made for each topside CS based on judgment regarding the likelihood of failure (CoF) and the consequence of failure (CoF).

6.1.2 The risk assessment is used mainly to define the inspection plans for all CS, but it can also be used as a screening tool to select topside structural elements for more detailed consideration, as and when more data is available.

6.2 Consequence of failure

6.2.1 The consequence of failure accounts for the impact in terms of life-safety, environment pollution and financial loss, should a failure occur.

6.2.2 ISO/DIS 19901-9 provides a consequence classification with respect to life-safety and environmental consequence only, leaving consideration of financial consequence to the discretion of the owner or operator.

Three levels of consequence of failure are considered, namely:

- Possible life-safety incident
- Possible high environmental pollution incident
- Possible low environmental pollution incident.

6.3 Likelihood of failure

6.3.1 The likelihood of failure should account for:

- characteristics of hazard actions
- loading exposure (e.g. accidental loading)
- present structural condition
- potential degradation mechanisms
- service history
- structural redundancy and alternative load paths

6.3.2 The likelihood of failure can be determined by a qualitative, a semi-quantitative or a quantitative method.

6.3.3 Qualitative methods use judgment, experience and knowledge on the topside structural aspects to categorize the CS susceptibility to failure.

6.3.4 Semi-quantitative methods categorize a topside CS based on a set of rules relative to its characteristic and condition data.

6.3.5 Quantitative methods compute explicit probabilities of failure based on code based Design Level Methods.

6.4 Risk ranking

6.4.1 The risk ranking usually uses consequence and likelihood categories and is presented in a risk matrix which shows the distribution of the CS risks throughout the platform.

6.4.2 Different sizes of risk matrix may be used (e.g. 3 x 3, 5 x 5, etc.), but the selected size should provide sufficient resolution to discriminate between the structural items assessed.

6.4.3 The risk categories on a risk matrix may take different formats with symmetrical risk categories, where likelihood and consequence have the same importance, or with asymmetrical risk categories where for example a higher weight is assigned to the consequence to reflect risk aversion.

Fig 3 shows typical examples of risk matrices.

7 Inspection Strategy

7.1 General

7.1.1 Inspection strategy & SIM policy

The SIM strategy should usually be consistent with the owner or operator SIM policy. The SIM policy refers to the overall objective of the owner/operator that must be achieved by the activities and processes involved in the SIM. It varies between two extreme goals:

- The first extreme goal aims at avoiding that major repair is undertaken. It puts emphasis on early detection of damage, which leads to more frequent inspections with preferably accurate inspection method especially NDE, while maintaining satisfactory structural integrity.
- The other extreme goal aims at reducing as much as possible the inspections frequency, while maintaining satisfactory awareness of the structural condition. To achieve this enough robustness is given to the structure by suitable design decision, including design margins, material selection and structural component redundancy.

7.2 Scope

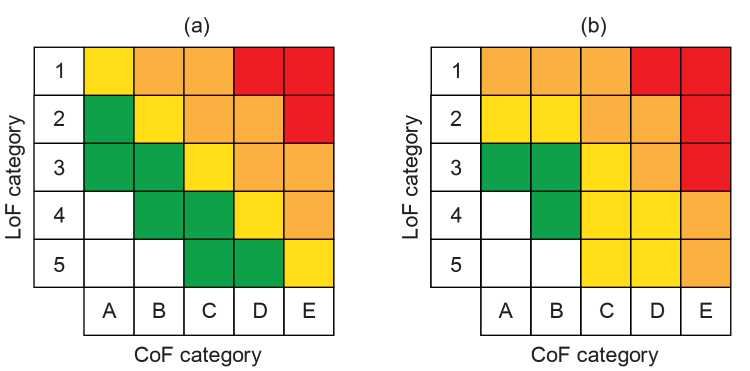
7.2.1 The overall inspection strategy includes many types of inspections namely:

- Baseline inspection to determine the as-installed condition of the structure
- Periodic or routine inspections to provide data on the present condition of the structure
- Special inspections that include:
  - inspections of known anomaly or damage to monitor their extension or repair effectiveness
  - inspections to verify the effectiveness of repairs to structural components and appurtenances
  - inspections to provide missing information for engineering assessment
  - inspections prior conversion or life extension
  - pre-decommissioning and pre-reuse inspections
- Unscheduled inspections following an extreme event or an accidental event.

7.2.2 The types of inspections, namely the baseline inspection, the special inspections and the unscheduled inspections, which are carried out once or under some conditions, should be implemented following the prescriptive requirements provided by the ISO (ISO/DIS 19901-9).

The risk-based SIM should focus on the definition of the periodic inspections strategy, which is the only inspection type that can be developed based on risk analysis results. However, the periodic inspection strategy should take into account the results of the other types of inspection.

Figure 3 : Example of Risk Matrix Formats; (a) symmetrical, (b) asymmetrical.



7.3 Periodic inspection strategy

7.3.1 General

The periodic inspection strategy includes the inspection interval and the inspection scope of work.

7.3.2 Risk-based inspection interval

The risk-based intervals should account for the following possible deterioration/degradation mechanisms:

- coating breakdown
- corrosion
- fatigue
- fretting
- PFP degradation
- physical damage (e.g. dropped object)
- bolt loosening/failure
- other material degradation
- vibrations.

Indicative risk-based inspection intervals that may be used for setting the topsides CS are provided in Tab 2.

Table 2 : Indicative risk-based inspection intervals (ISO/DIS 19901-9)

CoF	Possible life-safety incident	1 to 2 years	Annual	Six monthly
	Possible high environmental pollution incident	1 to 3 years	1 to 2 years	Annual
	Possible low environmental pollution incident	1 to 5 years	1 to 5 years	1 to 2 years
		Low	Medium	High
		LoF		

7.3.3 Inspection scope of work

The type of inspection (i.e. GVI, CVI and/or NDE) to be used with the risk-based interval should be selected based on the type of expected deterioration/degradation and the present known condition of the topsides CS. Usually GVI should be carried out first. Then, close-up inspection i.e. CVI or NDE are performed where GVI cannot determine the extent of the damage.

Topsides elements selected for inspection can be based on:

- criticality of member or joint
- effect on global structural integrity
- consequence of failure
- degree of redundancy
- stress state complexity
- strength level
- degree of plastic straining
- exposure to fatigue loading
- service temperature
- service function of the element e.g. support of generator and turbine, support of safety critical element.

Topsides components, which are commonly pre-selected for inspection, include:

- main deck girders
- transitions to substructures
- transition frames for concrete gravity base structures
- module trusses and support units
- accommodation module
- derrick
- bridges
- flare booms and vent stacks
- cranes
- helidecks
- lifeboats and other evacuation, escape and rescue equipment
- laydown areas
- hull-deck connections
- changes to equipment weights and support location points and deck load
- riser guards
- monorails
- lifting lug.

7.4 Particular considerations regarding the inspection planning of topsides structures

7.4.1 General

Specific features related to the inspection of topside structures should be addressed in planning the inspection, namely:

- the inspection interfaces
- inspection required for non-structural safety critical elements
- the not inspectable structural components.

7.4.2 Inspection interfaces

The inspection of the topsides structures usually interfaces with many other inspection activities and production activities.

a) There is an interface between the inspection of the topside structures and the inspection of the substructure. Those parts of the platform structure usually have specific inspection strategy and their respective inspection scopes of work are executed separately. However, especially for the fixed platforms, the damage observed on topsides structures and splash zone structures can trigger inspection of the underwater structure to look for possible impact damage from falling debris from the above water structure.

b) There is an interface between the actual risk-based inspection strategy and specific inspection requirement for some topside structures e.g. crane, helideck, appurtenances, personnel safety devices. For example, the inspection of cranes is covered by the international standards ISO 4309, API-RP-2D and FEM (European Materials Handling Federation). Inspections of helidecks are usually performed for helideck certification. Appurtenances e.g. risers, pipelines have specific standards addressing their inspection requirements e.g. ISO 16440, API 570. Inspection requirement are provided for attachment tie-down in API and for escape routes in API 54. However, when the actual risk-based inspection requirement is in competition with specific inspection requirement applicable to a given structure, the latter should be applied, unless otherwise specified, but this should be clearly justified.

c) The inspection of the connections between the equipment or pipework and their support structures is required, both in the inspection of the support structure and in the inspection of the equipment or pipework. Therefore, in defining the inspection scope of work, one should be aware of the possible inspection of support/equipment connections already carried out as part of the equipment inspection program, to take into account their results or not to perform unnecessary inspection.

d) There is an interface between the actual inspection program for topside structure and inspection activities performed by other disciplines. Therefore, there may be an opportunity to perform topside structure inspection together with another inspection activity. For example, a trained visual inspector, who is certified for survey of both structures and process facilities, could inspect both the structure and the exterior of the process facilities.

e) The inspection activity on some topsides structures, e.g. flare boom, heat shield, usually require platform shutdown. Therefore, the expected downtime should be considered in planning those inspections so as to reduce production loss if necessary.

7.4.3 Inspection required for non-structural safety critical elements

ISO requires that supports for equipment, e.g. safety critical communications, electrical and firewater systems, etc, be inspected as part of the inspection of the topsides structures. In fact, even if they are not of a structural nature, they are likely to be safety critical. In particular, attention should be paid to their connections to the platform structure, which can be affected by the effects of accidental loading, including strong vibration.

7.4.4 Not inspectable structural components

Some structural joints are classified as not inspectable especially because they are hidden due to their location. They are usually designed with larger fatigue design safety factor to ensure higher strength against degradation mechanism. Such structural components are normally excluded from the inspection scope of work. However, some information on their likely condition can be deduced from an external inspection.

7.5 Maintenance strategy

7.5.1 ISO recommends implementing structural maintenance strategy, in complement to the inspection plan, in order to mitigate possible significant degradation mode that can reduce the structural strength of critical structures. This will result in a reduction of the inspection scope of work.

7.5.2 The maintenance strategy should include:

- protective coating systems and fabric maintenance program
- grating replacement schedule.

7.5.3 The maintenance tasks and schedules should be developed based on good practices, equipment vendor guidelines and owner risk tolerance criteria.

7.5.4 Risk-based coating maintenance program may be developed to optimize the maintenance of the protective coatings, which is resource demanding and costly (Axelsen, et. al., 2009).

8 Inspection Program

8.1 General

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

8.1.2 Inspection specification should, as a minimum, include:

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

8.2 Inspection specifications

8.2.1 General visual inspection

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.

8.2.2 Coating survey (including PFP)

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. cladding or elastomer on the splash zone members and jacket legs, paint on the conductors), and record the locations and extent of coating deterioration.

8.2.3 Attachment tie-down points

If specified in the topsides inspection scope of work, a walk-down survey to assess the vulnerability of personnel safety equipment and supports to damage from shock loading and strong vibration induced from extreme or abnormal metocean or seismic events or accidental loadings shall be performed.

Walk-down is primarily a visual inspection and may be performed to coincide with the routine topsides inspection. The support can be permanent or temporary and the data should be recorded to allow engineering personnel to evaluate the ability of the tie-down to resist lateral loads.

8.2.4 Escape routes

During the topsides inspection a visual survey of the personnel escape routes shall be performed. Escape routes consist of open decks, walkways, stairs, and landings. The routes should be established and surveyed to confirm clear access to the escape routes is provided from locations on the structure. Crane transfer carriers and connections should be examined for signs of damage or deterioration.

8.2.5 Deck elevation survey

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

8.2.6 Close visual weld/joint survey

If specified in the inspection scope of work, a close visual weld/joint survey consisting of a visual examination of the selected weld/joint in the jacket shall be performed. 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.

8.2.7 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).

8.2.8 Bolted connection inspections

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

Note 1: It is also important that best industrial practices be applied to ensure the tightness of the bolted connection since former techniques (e.g. flogging spanners) have proven to increase likelihood of hydrocarbon releases and/or joint failures.

Some best industrial practices are set out in the guideline “Mechanical Joint Integrity - Competence Guidance” published by the UK organization “Step Change in Safety”.

8.2.9 Aerial surveys

Unmanned aerial vehicles (UAVs) may be used for high-altitude inspections on structures (e.g. flare booms and derrick). However, such surveys should be verified and certified for reliability and fitness-for-purpose. Available recommendations of the Society on the use of Remote Inspection Techniques (RIT) are provided in App 1 of NR533 “Approval of Service Suppliers”.

SECTION 3 RISK-BASED INSPECTION PLANNING METHOD

1 General

1.1 Purpose

1.1.1 The purpose of the method described in this Section is to perform risk assessment and develop inspection strategy for offshore topsides structures.

1.1.2 The risk assessment and the resulting risk-based inspection strategy are focused on the structural systems, structural sub-systems and structural components that have been identified as critical for the safety, the environment and the production.

1.2 Scope of application

1.2.1 The risk-based inspection (RBI) method is applicable to:

- the above water structures of fixed platforms including the below deck structure (i.e. splashzone) and the topsides structures on the deck
- the topsides structures on the deck of floating units
- the bridges
- and the connecting structures.

1.2.2 The risk assessment developed as part of the method can be carried out on structural components or on groups of structural components.

1.2.3 The structural components are classified as follows:

- structural member types
  - cylindrical tubular members
  - members with non-cylindrical sections e.g. plates, plate girders, box girders, profiles, stiffened plate structures and stressed skin structures.
- connections
  - welded connections between members
  - bolted connections.
  - castings
  - forging.

1.2.4 Relevant groups of structural components include:

- groups of structural components that fall under typical categories, for example:
  - primary, secondary and tertiary structures
  - deck plates, gratings and handrails
  - means of access and associated handrails and stairs
  - ancillary structures
  - foundations of safety critical elements.
- groups of structural components that provide specific structural function to equipment and appurtenances, for example:
  - equipment connections
  - pipework connections
  - risers / conductors guides
  - protection frames
  - …
- groups of structural components that belong to specific areas worth being considered as a whole in SIM analysis, for example:
  - main and secondary escape routes
  - muster area
  - …

1.2.5 The method includes also in the scope the connections to the platform structure of non-structural elements such as the supports for equipment e.g. safety critical communications, electrical and firewater systems, etc. They are included following ISO recommendation since they are likely to be safety-critical and can be affected by the effects of accidental loading, including strong vibration.

2 Implementation

2.1 General

2.1.1 The process for implementing the RBI method contains three main steps:

- an initial RBI workshop
- the risk assessment
- the definition of the inspection strategy.

Since risk is dynamic (i.e. changes with time), it is important to maintain and update an RBI assessment to ensure that the most recent inspection, process, and maintenance information is included.

2.2 RBI workshop

2.2.1 General

An RBI workshop must be conducted at the beginning of an RBI project for planning the RBI assessment.

This workshop should allow the following tasks to be carried out:

- an RBI training
- the organization, the role and responsibilities of the RBI team
- the achievement of an agreement on key elements of the RBI.

2.2.2 RBI training

A training on the RBI method should be deliver as part of the initial RBI workshop to the stakeholders likely to be involved such as inspection personnel, structural engineers, operating personnel and other stakeholders involved in the decisions on managing risks.

The purpose of this training is to show the audience the concepts and principles embedded in the RBI method and to help them understand the risk assessment process in order for them to be able to appraise and to accept the RBI results.

2.2.3 RBI team

The RBI method involves a multi-disciplined approach since it requires data gathering from many sources, many specialized analyses and risk-management decision-making. Therefore, the team members should have skills and backgrounds in the following disciplines:

- Risk analysis
- Offshore structural engineering
- Deterioration/degradation mechanisms and failure modes
- Offshore maintenance and inspection techniques and technologies
- Material, corrosion and coating engineering
- Environmental, safety and health systems and regulations
- Operations.

It is essential to have a team leader whose main functions should be:

- to coordinate the team members
- to facilitate the RBI meetings that will take place during the RBI project
- to ensure that the study is properly conducted
- to integrate the inputs and outputs into the final RBI report.

It is essential that a representative of the Society be involved for the RBI assessment of topsides structures of floating units within the class rule.

The other team members should participate and contribute to the RBI analysis to the extent of their skills. They should carry out the following tasks with respect to their area of competence:

- providing data/information required
- verifying/checking soundness of data and assumptions
- assessing the structural condition
- assessing the risk level
- verifying/checking adequacy of the resulting inspection plan.

As part of the RBI team make-up, some knowledgeable people may be identified to serve as advisors. They are not part of the core RBI team, but they may be consulted to provide recommendations on ways to address specific issues related to their area of expertise.

RBI assessment requires also the commitment and the cooperation of the operating organization. It is essential that the Offshore Installation Manager (OIM) be involved.

2.2.4 Key elements of the RBI analysis

As part of the initial RBI workshop it is important that an agreement be achieved among all the stakeholders on the following key elements of the RBI analysis:

- the objective of the RBI assessment
- the risk acceptance criteria / the risk matrix format
- the CS selected for the RBI assessment
- the performance standards to be applied
- the data requirements
- the type or level of risk assessment method to be used
- the time and resource required
- the deliverables
- the period of validity of the RBI assessment and when it should be updated
- the applicable codes and standards.

2.3 Risk assessment

2.3.1 General

The risk assessment process involves the following steps:

- data collection
- risk rating

The risk assessment may start with an initial screening of the whole structure to select the structural items on which the risk assessment will be focused.

2.3.2 Initial screening

If the scope of the RBI assessment is the entire topsides structure, a screening of all the structural items will be conducted first to identify those structural items that are most important in terms of risk. Those ones will then be selected for the application of the RBI assessment so that time and resources are more effectively used.

The initial screening provides also insight about the level of assessment that may be required for the selected structural items.

The initial screening can be performed using a simplified qualitative risk assessment or through HAZID sessions.

2.3.3 Data collection

Typical data required for the risk assessment include:

- initial design criteria
- robustness/redundancy level
- degree of uncertainty on the as-installed condition
- materials of construction
- structural strength data (e.g. computed ultimate strength and fatigue strength)
- coating, cladding, and insulation data
- inspection, repair and replacement records
- damage mechanisms, rates, and severity

- data on the conditions in the vicinity of the structure, including:
  - fluids inventory
  - temperature
  - operations
  - drainage systems
  - safety systems
  - detection systems
  - personnel density
- business interruption
- repair
- replacement
- environmental remediation.

Those data may be gathered from various sources, including:

- design, construction and installation records
  - reports
  - drawings
  - engineering specification sheets
  - codes and standards used
  - mill certificates
  - equipment and appurtenances layout
  - installation logs
- structural assessment reports/drawings
- inspection records
- operating logs
- MOC records
- industry specific structural failure data
- industry databases
- hazards analysis report e.g. QRA studies
- anomaly register
- risk register.

If a required data is missing or inaccurate, survey should be conducted to collect the required information, otherwise conservative assumption should be taken during the risk assessment.

2.3.4 Risk rating

The RBI method of this document applies the risk assessment method described in Article [3].

2.4 Inspection strategy

2.4.1 General

An inspection plan must be developed for each structural item selected for the RBI assessment.

The inspection strategy must cover the service lifetime of the offshore unit and must be reviewed periodically throughout this lifetime to identify whether changes are required and apply them.

It must specify:

- the inspection interval or inspection schedule
- the inspection technique
- the inspection coverage when close-up inspection is required on a group of structural components

The risk-based inspection strategy to be used by default is set out in Article [4].

The inspection strategy can be modified by consideration of the regulation requirements and the operational feasibility. Therefore, it is important that operational team members be involved at this stage to demonstrate that the final inspection strategy conforms to regional regulations and is workable based on location infrastructures and capabilities.

2.4.2 Inspection interval

The inspection interval should be based on standards recommended risk-based inspection intervals or on general industry experience. If specific inspection intervals are selected, technical justification should be provided to support the choice made. This technical justification may be based on consideration of the possible degradation mechanisms, the deterioration rate and the detection capability of the selected inspection method.

2.4.3 Inspection technique

The inspection technique should be selected by a qualified personnel based on the type and size of the expected deterioration.

The Society feedback and agreement is required for floating unit within the class rule.

2.4.4 Inspection coverage

The inspection coverage may be given by:

a) A percentage of structural details to inspect so as to have representative condition data of the structure.

   This representative percentage should be based on best industry practice and standards; otherwise technical justification of the choice made should be provided.

b) A selection of location where the likelihood of damage is higher.

   Those location should include:

   - area of suspected or known damage from the service history or from industry experience
   - area with higher stresses or lower fatigue life

   Those location may be selected based on a local risk ranking of the structure's components.

2.5 RBI updating

2.5.1 General

It is important that an effective MOC process be in place that identifies when a RBI updating is necessary.

A frequency at which the RBI assessment is to be reviewed must be defined and agreed at the initial set up of the RBI.

2.5.2 When to conduct an RBI updating

An RBI updating is required:

- after significant changes in process conditions, damage mechanisms/rates/severities or RBI premises
- after a set period of time (e.g. period of validity of the current inspection plan, an establish maximum time period for the RBI updating)
- After implementation of risk mitigation strategies.

3 Risk Assessment Method

3.1 General

3.1.1 The risk assessment is to be carried out for each of the identified CS.

3.1.2 The likelihood of failure is assessed by a rule-based scoring method. The scoring rules should be set up according to the performance standard required by the owner /operator.

Structural assessment results if available could allow improvement of the likelihood scoring.

3.1.3 The consequence of failure is given by an exposure category with respect to the impact in terms of life-safety, environment pollution and financial loss.

3.2 Performance standard

3.2.1 General

An example of a minimum performance requirement for a given CS in operational phase is provided here-below. It is given in terms of a minimum acceptable degraded condition of the structure and of the protective coating system (e.g. corrosion protection coating, PFP) eventually applied on that structure.

Any specific performance standard defined by the owner must ensure at least the same safety level as this minimum performance standard.

3.2.2 Acceptance criteria for the condition of corrosion-protective coating systems

The corrosion coating systems are required to be maintained in a FAIR condition, corrosion coating condition being defined as follows:

- GOOD condition with only minor spot rusting
- FAIR condition with local breakdown at edges of stiffeners and weld Connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for POOR condition
- POOR condition with general breakdown of coating over 20% or more of areas or hard scale at 10% or more of areas under consideration.

More detailed ranking system of the corrosion-protective coating condition could be found in App 3.

3.2.3 Acceptance criteria for the condition of PFP

PFP condition is required not to reach severity level 2 according the classification of PFP condition provided in App 3.

3.2.4 Acceptance criteria for the condition of the structure

The method of this document proposes the following minimum criteria with respect to the strength of the CS to be applied in operation:

- The strengths of the primary structural components, which are part of the CS, are required to satisfy the DLM component-based criteria.
- The secondary and tertiary structural components of the CS, when it is a structural system or group of structural components, are taken together and the proportion of components the strength of which don't comply with the DLM criteria is required to be less than 10%
- The degraded strengths of the failed secondary or tertiary structural components are required to be still larger than 75% of the allowable strength specified by the DLM criteria.

However, the DLM criteria can be reduced by removing the safety factors and/or by using mean rather than nominal yield stress, but this should be justified from the operational experience.

The 90% of secondary or tertiary structural components is arbitrarily chosen, the most important being the integrity of the primary structural components which mainly bear the loadings, while the number of damaged secondary or tertiary structural component is indicative of a degradation process going on, which may affect more structural components including primary members.

The condition of the structure can be assessed qualitatively using a relevant classification of the extent of degradation on the structure given by the size or/and the number of defects. It can be assessed quantitatively also by the residual strength of the degraded structure.

3.3 Likelihood of failure

3.3.1 General

The assessment process consists in, first assigning a score to likelihood using the following formula:

$$S = \sum_i w_i \cdot S_i$$

where:

S_i : Partial scores assigned to influencing factors

w_i : Weights to account for how sensitive is the overall likelihood to the factors.

Then, a likelihood category is allocated to the CS under consideration with respect to the range in which the overall score lies.

The ranges for the likelihood categories and the weights of the influencing factors are calibrated using an arbitrary set of representative structures the likelihood level of which are assumed based on expertise and experience.

3.3.2 Influencing factors

The factors which affect the likelihood are divided as follows:

- Baseline condition
  - Design practice
  - Robustness
  - Extent of fabrication and installation inspections
  - Ultimate strength
  - Fatigue strength.

- Current condition
  - Design condition deviation
  - Extent of degradation of the protective coating system (e.g. corrosion protection coating, PFP)
  - Extent of damage on the structure
  - Level of surface corrosion
  - Penalty factor accounting for compliance with due inspection year
  - Penalty factor accounting for compliance with required inspection method.
- Degradation exposure
  - fatigue sensitivity
  - Damage susceptibility
  - Affected by heat
  - Subjected to low temperature
  - Severity of the corrosion environment
  - Potential for internal corrosion.
- Modifications and upgrades
  - Weight change due to addition or deletion of equipment
  - Structural modification
  - Change to operational procedures
  - Change to regulations, standards and specifications.

3.3.3 Design practice

The method assumes that the topside structures were designed in conformance with the appropriate international standard especially the ISO 19901-3. The design requirements of the ISO 19901-3 include:

- Deck elevation requirements for topsides on fixed platforms and green water requirements for topsides on floating structures
- Design criteria for structural components
- Appropriate design situations and load cases to be considered for structural systems such as flare tower, helideck, crane support, derrick, bridges and bridges bearings, anti-vibration mounting, walkways, laydown areas, maintenance areas, muster areas and lifeboat stations
- Specific requirements for corrosion protection system, fire protection system, deck drainage system
- Requirements for the relevance of system interface assumptions
- Requirement to correctly take into account the action due to drilling operation on safety critical elements and protective coatings
- Requirements for structure sited near heat producing facilities e.g. flare and exhaust dust
- Material selection requirement with reference to the requirements laid out in the ISO 19902.

The compliance of the design practice with the appropriate international standard e.g. ISO 19901-3 can be assessed using checklists based upon the requirements laid out in the standard.

In case of none compliance with any of the design criteria, expert analysis should be undertaken to determine how this increases the baseline likelihood of failure of the affected structures.

3.3.4 Robustness

The robustness is to be considered at the design stage. The requirement related to robustness for the design of topside structures implies that the structural integrity in damaged state is sufficient to allow a process system close-down, or a safe evacuation, or both. Robustness is preferably achieved by an appropriate bracing pattern that provides alternative load paths.

The level of robustness of the topside structural items is assessed qualitatively based on expert judgment.

3.3.5 Extent of fabrication and installation inspections

The method assumes that in-process inspections were performed in conformance with the appropriate international standards (e.g. ISO, ASTM and NACE typically for corrosion protection coatings). Many standards are involved in the specifications for in-process inspections, each one addressing a typical issue in the process. They usually provide:

- Requirements on the inspections to be conducted through the coating application process, including:
  - Specifications and test methods for coating material
  - Recommendations for the inspection of the pre-existing condition of the surface of steel substrates
  - Recommendations for the inspection of the surface preparation on steel substrates
  - Recommendation for the inspection of mixing, thinning and coating application
  - Specifications and test methods for the performance of the coating system after application
- NDT inspection requirement for welding including minimum extent of weld inspection with respect to the type of structural component and the NDT technique (ISO 19902).

The compliance of the in-process inspections with the appropriate international standards can be assessed using checklists based upon the requirements laid out in the standards.

In case of none compliance with any of the standards' requirements, expert analysis should be undertaken to determine how this increases the baseline likelihood of failure of the affected structures.

3.3.6 Ultimate strength

This factor accounts for the ultimate capacity obtained from a structural analysis especially the last structural assessment of the topside structure under consideration.

The ultimate strength of a CS is given by the unity check (UC) value. If the CS is a structural component (e.g. primary member) its UC value is to be used to define the static strength, while if the CS is a structural system or a group of structures a percentile of the UC of its structural components is used to define the static strength in order to conform to the principle adopted for defining structural performance standard. By default, the 90%-percentile is used.

3.3.7 Fatigue damage ratio

This factor accounts for the likelihood of fatigue crack occurrence on the structural components especially welded tubular joints.

If the CS is a structural component (e.g. primary member) its fatigue damage ratio value is to be used, while if the CS is a structural system or a group of structures a percentile of the fatigue damage ratio of its structural components is used, in order to conform to the principle adopted for defining structural performance standard. By default, the 90%-percentile is used.

3.3.8 Design condition deviation

This factor accounts for deviation of the condition of a structural component from that used for the design e.g. change in loading.

This factor is assessed in terms of how large the deviation is. However, if the deviation is larger beyond an acceptable limit, a structural assessment must be considered to check fitness-for-service before proceeding with the analysis.

3.3.9 Extent of degradation of its protective coating system

This factor accounts for the extent of degradation found from previous inspections.

The extent of detected degradation is rated qualitatively e.g. intact, minor, severe,… The criteria defining the qualitative extent should be set up according to the performance standard required by the operator or owner.

3.3.10 Extent of damage on the structure

This factor accounts for the extent of structural damage found from previous inspections. The extent of detected damage is rated qualitatively e.g. intact, minor, severe,… The criteria defining the qualitative extent should be set up according to the performance standard required by the operator or owner.

3.3.11 Level of surface corrosion

This factor accounts for the corrosion wastage found on the structure from previous inspections. The extent of surface corrosion is rated qualitatively e.g. no, minor, severe,… The criteria defining the qualitative extent should be set up according to the performance standard required by the operator or owner.

3.3.12 Penalty factor accounting for compliance with due inspection year

This factor penalizes structural components which have not been inspected at the time required by the current inspection plan and are still not inspected at the time of the risk assessment. This induces uncertainty on the current condition of the structural components under consideration.

3.3.13 Penalty factor accounting for compliance with the required inspection method

This factor accounts for the accuracy of the inspection method used.

3.3.14 Degradation exposure

All the degradation exposure factors (namely: fatigue sensitivity, damage susceptibility (e.g. mechanical handling way, laydown area, drop object...), affected by heat, subjected to low temperature, severity of the corrosion environment, potential for internal corrosion) have the same format of scoring rule. The scoring rule is defined in terms of whether the structural component is exposed to a degradation mechanism, and whether a measure is in place to reduce the identified degradation susceptibility.

3.3.15 Modifications and upgrades

This scoring rule reflects how the loads and potential hazards on the structure, the capacity of the structure and the structural performance criteria are affected by the modifications and upgrades carried out and their resulting influence on the LoF.

3.4 Calibration process of the LoF scoring

3.4.1 General

A calibration process allows computing the weights of the influencing factors and the limits values of the ranges of the scores for the LoF categories.

In the current scoring process the range of the scores for the likelihood category are fixed. Therefore, the calibration of the scoring formula consists in finding the weight values that yield a result as close as possible to the expected LoF category.

The calibration process involves the following steps:

a) select influencing factors with larger importance for the likelihood

b) generate a sample of structural data with respect to the parameters of the selected influencing factors

c) assign a LoF category to each one of the sample data based on expertise and experience

d) compute the weights of the selected factors by a least square method so that the scoring formula provides results as close as possible to the expected ones

e) validate the computed weight on a generated sample set involving all the structural integrity parameters.

3.4.2 Selection of factors for the calibration

Factors with larger importance are selected. They should allow a likelihood category corresponding to typical values of their respective parameters to be perceived. These are factors for which simple rules can be defined on how they influence the likelihood. For example, such factor may move the structural component from one category to another when its parameters are changed from the lowest to the highest value.

Several important factors may be considered having the same weight. In those cases, only one of them should be selected for the calibration, and then its computed weight will be allocated to the others.

The weights of the remaining factors with smaller importance will be allocated marginal values in comparison to larger importance factors selected for the calibration. They can be assigned a fraction of the lowest computed weight so that they could not allow a structural component to move from one category to another over the full range of their variation.

3.4.3 Calibration set

The sample set of structural component for the calibration is given by a certain number of relevant combinations of the parameters of the selected influencing factors.

3.4.4 Expected category allocation

The sample of structural component defined for the calibration is submitted to knowledgeable people so they can provide a likelihood category from their expertise and experience. Thus, the provided categories will be all the more suitable as their level of expertise is higher.

Moreover, specific requirements from the operator or owner with respect to his risk perception or risk aversion can be taken into account in the allocation of an expected likelihood category. In this case, it must be ensured that the minimum acceptable performance is still met.

3.4.5 Weight computation

The weights of the selected factors are computed by a least square method so that the scoring formula provides results as close as possible to the expected ones. However, it is recommended to ensure that when the scoring provides likelihood different from expected, it should still be conservative.

Those remaining factors which are considered of similar importance as one of the selected one are allocated the corresponding same weight. The other factors with smaller importance are allocated marginal values with respect to lowest weight of the factors selected for the calibration.

3.4.6 Validation

A sample set is generated involving preferably all the structural integrity parameters. Their respective LoF category is computed with the obtained scoring formula. Those computed LoF are then checked by knowledgeable people in order to validate the scoring formula.

3.5 Consequence of failure

3.5.1 General

The consequence of failure accounts for the impact in terms of life-safety, environment pollution and financial loss.

3.5.2 Life-Safety consequence

The life-safety consequence level depends on whether offshore personnel are exposed or not when a structural failure occurs.

The factors which affect the life-safety consequence are:

- the manning status of the platform (only for fixed platforms)
- the possibility of fatalities or injuries in case of structural failure e.g. failure of walkways
- the possibility of structural failure escalating to hydrocarbon blast and fire
- the possibility of structural failure causing release of toxic smoke or gas.

3.5.3 Environmental consequence

The environmental consequence level depends on the expected volume of hydrocarbon released as the result of the structural failure.

The factors which affect the environmental consequence are:

- the platform type (only for fixed platform) including drilling and/or production, storage platforms
- the capacity of the processing and / or storage facilities supported by the platform
- the proximity of the failing structure to major process or storage equipment or to major pipework
- mitigation measure that is in place to reduce the environmental consequence.

3.5.4 Financial consequence

The financial consequence level depends on the expected financial loss as the result of the structural failure and/or repair.

The factors which affect the financial consequence are:

- the structural importance
- accessibility for repair
- additional repair cost e.g. logistic costs.

3.6 Risk ranking

3.6.1 The risk ranking uses by default a 5 x 5 asymmetrical matrix (see Fig 1).

Figure 1 : Default risk matrix format.

Likelihood					
5	IV	IV	IV	V	V
4	III	III	IV	IV	V
3	II	II	III	IV	V
2	I	II	III	III	IV
1	I	I	III	III	IV
	1	2	3	4	5
	Consequence				

3.6.2 Owner or operator specific risk matrix is also applicable provided that, on one hand, the likelihood scoring method is calibrated against it; on the other hand the consequence is categorized according to it.

4 Inspection Strategy

4.1 Default risk-based inspection intervals

4.1.1 The method proposes using by default risk-based inspection intervals not larger than those set out in Fig 2.

Figure 2 : Maximum risk-based inspection intervals [in years] based on ISO.

(a)

Likelihood (rows) / Consequence (columns)

IV	IV	IV	V	V
III	III	IV	IV	V
II	II	III	IV	V
I	II	III	III	IV
I	I	III	III	IV

(b)

Likelihood (rows) / Consequence (columns)

1	1	1	*	*
2	2	1	1	*
3	3	2	1	*
5	3	2	2	1
5	5	2	2	1

* Mitigation required

4.2 Default inspection scope of work

4.2.1 The method of this document recommends that the type of inspection technique be selected with respect to the risk level as shown on Fig 3.

Figure 3 : Minimum requirement for the inspection method to be selected.

Likelihood (rows) / Consequence (columns)

NDE	NDE	NDE	*	*
CVI	CVI	NDE	NDE	*
GVI	GVI	CVI	NDE	*
GVI	GVI	CVI	CVI	NDE
GVI	GVI	CVI	CVI	NDE

* Mitigation required

4.3 Specific inspection plan

4.3.1 Owner specific risk-based inspection intervals and scope of work must achieve at least the same level of safety than the default risk-based inspection plan.

5 Inspection program

5.1 General

5.1.1 The implementation of the inspection program is under the responsibility of the owner or operator who is in charge of conducting the detailed inspection work scope to complete the activities defined in the inspection strategy. Therefore, this article is not part of the RBI method developed by the Society.

5.1.2 This article is provided for information in order to draw attention to important requirements for the implementation of the inspection program, which may be useful when the Society is required to appraise the inspection program or is involved in its specifications.

5.1.3 The inspection program contains two main elements:

- its specification
- its execution

5.2 Specification of the inspection program

5.2.1 Some requirements for the inspection tasks should be established in advance to enable effective execution of the inspections. The specifications to be provided as minimum are set out in Sec 2, [8.1.2].

5.2.2 In addition, it is recommended to provide detailed field guidance for each survey in the form of detailed inspection work packs or checklists. This field guidance identifies each of the individual inspection locations, the inspection methods and provides a means to document the observations. It includes also details on required access, cleaning, and equipment required to successfully execute each inspection within the survey.

5.2.3 All the inspection instructions may be issued as an inspection workbook, including drawings, procedures, reporting formats and calibration logs.

5.3 Execution of the inspection program

5.3.1 The inspection technicians and engineers and their associated companies conducting the inspections and reviewing the results must be qualified in accordance with owner requirements.

5.3.2 If during the course of an inspection program, anomalies are discovered that can potentially affect the structural integrity, personnel should perform an evaluation to determine if and when additional inspection and/or remedial measures should be performed. Additional inspection can require use of more detailed survey techniques.

APPENDIX 1 TYPICAL TOPSIDES STRUCTURAL SIM DATA

1 Typical examples of topsides structures SIM Data

1.1 Design data

1.1.1 Typical examples of design data include:

- original and present owner
- original and present platform use and function
- location, water depth and orientation
- number of wells, risers and production rate
- other site-specific information, manning level, etc
- design contractor and date of design
- design codes
- basis of design
- design criteria (e.g. metocean, seismic, collision, ice, fire and blast)
- design drawings and material specifications
- design structural models and analysis reports
- operational criteria - topsides arrangement
- appurtenances - number, size list and location as designed.

1.2 Fabrication and installation data

1.2.1 Typical examples of fabrication data include:

- fabrication contractors details
- approved for construction drawings or as-built drawings
- inspection results following fabrication/construction
- fabrication, welding, and construction specifications
- mill certificates and material traceability documentation
- construction tolerances and compliance/deviation records
- weld inspection records
- anomaly, defect, repair and remedial action records
- quality assurance records
- material data sheets
- weighing reports.

1.2.2 Typical examples of installation data include:

- installation contractor details and date of installation
- records of field modifications, damage or repairs
- transportation records (severe weather / motions).

1.3 Condition data

1.3.1 Typical examples of historical condition data include:

- post-installation / baseline inspection records
- in-service inspection records
- in-service structural maintenance records
- strengthening/modification/repair (SMR) data - descriptions, analyses, drawings, and dates
- condition monitoring data.

1.3.2 Typical examples of as-is condition data include:

- all decks - actual size, location and elevation
- all decks - existing topsides arrangement
- production and storage inventory
- above water survey results
- appurtenances (i.e. list, sizes, and locations)
- structural MOC
- mitigation plans
- maintenance records
- inspection scopes of work.

1.4 Operational data

1.4.1 Typical examples of operational data include:

- operational loading history - records of weight additions and removals
- metocean loading history - extreme events including descriptions dates and platform performance during event
- seismic loading history (if applicable) - descriptions, dates and platform performance during event
- accidental loading history - collisions, dropped objects and other accidental loads
- loading and offloading operations (e.g. crane reach, faces of platform used)
- drilling structures and future drilling campaigns
- access limitations (e.g. exhausts, flares, underdeck areas)
- vessel operations
- helicopter operations
- walk-to-work or bridge landing structures and their use
- caisson pump retrieval and maintenance operations
- wells/conductors in use on the platform
- well intervention philosophy/strategy
- additional modules, caissons, conductors
- expanding or over utilized laydown areas
- crane replacements
- tie-backs from other platforms or fields
- crane operation log book
- operational incident data
- equipment layout
- management of change documentation.

1.5 Engineering data

1.5.1 Typical examples of engineering data include:

- damage evaluation data - descriptions, analyses and dates
- hazard analysis
- engineering evaluation screening records
- anomaly register
- assessment basis
- assessment models
- risk registers
- cost-benefit analyses
- incident root-cause analyses
- performance levels
- structural models
- structural analysis reports.

APPENDIX 2 TYPICAL CRITICAL STRUCTURES

1 Typical examples of CS

1.1 General

1.1.1 Part of the platform structure whose failure can cause or contribute substantially to a major accident is safety and environmentally critical, as is a part which is intended to prevent or limit the effect of a major accident.

Typical examples of CS in terms of the possible consequence of their failure are provided in the sequel.

1.2 Major accident

1.2.1 Examples of CS that can collapse and result in a major accident (five or more fatalities):

- topsides primary steel that provides direct support and stability of the living quarters or temporary refuges (individual members or joints in a topsides are not CS)
- temporary refuge
- helideck and helideck support structure
- bridges and bridge support structure
- TEMPSC (Totally Enclosed Motor Propelled Survival Craft) davits and support structure
- muster area walkways and support structure.

1.3 Major environmental event

1.3.1 Examples of CS that can fail and result in a major environmental event:

- conductors
- conductor centralizers
- conductor guide framing.

1.4 Major accident prevention or mitigation

1.4.1 Examples of CS that are intended to prevent or limit the effect of a major accident, directly or by loss of a prevention or mitigation barrier:

a) Direct escalation:
   - risers, riser clamps, riser guides and emergency shutdown valve supports
   - hydrocarbon pipework supports
   - process equipment tie-downs.

b) Escalation due to loss of a mitigation barrier:
   - riser and conductor protection frames
   - fire wall and fire wall supports
   - blast wall and blast wall supports
   - fire pump enclosures
   - fire pump caissons and supports or guides
   - dropped object protection.

1.5 Personnel safety

1.5.1 Examples of CS that can fail and result in one or more fatalities include:

- walkways (including their supporting structure), handrails and stair treads
- drilling rigs (and masts), tie-downs and skid beams
- communication towers and support structure
- crane pedestals and support structure
- exhaust stack support structure
- runway beams and their connections.

1.6 Financial loss

1.6.1 Examples of CS that can fail and result in significant financial loss to the owner:

- flare boom and support structure
- caissons and supports (other than fire pump caisson)
- primary topside structure (other than that providing direct temporary refuge support).

APPENDIX 3 ASSESSMENT OF COATING CONDITION

1 Corrosion protection coatings

1.1 General

1.1.1 Three standardization societies have provided grading systems for the assessment of coating condition, namely ISO, SSPC and ASTM.

1.2 ISO

1.2.1 The ISO provides a series of standards for the evaluation of degraded corrosion protection coatings due to aging or weathering. The ISO 4628-1 (ISO, 2016) gives the principles of the rating system and ISO 4628-(2 to 8 and 10) provide pictorial guidelines for the assessment of particular type of coating degradation as follows:

- ISO 4628-2 for the assessment of degree of blistering
- ISO 4628-3 for the assessment of degree of rusting
- ISO 4628-4 for the assessment of degree of cracking
- ISO 4628-5 for the assessment of degree of flaking
- ISO 4628-6 for the assessment of degree of chalking by tape method
- ISO 4628-7 for the assessment of degree of chalking by velvet method
- ISO 4628-8 for the assessment of degree of delamination and corrosion around a scribe or other artificial defect
- ISO 4628-10 for the assessment of degree of filiform corrosion

1.2.2 Principle of ISO rating system

The ratings is based on a numerical scale ranging from 0 to 5, 0 denoting no defects or changes, and 5 denoting defects or changes so severe that further discrimination is not reasonable.

Sec 3, Tab 1 to Sec 3, Tab 3 show the rating scheme for quantity of defects, size of defects and intensity of change respectively.

Table 1 : Rating scheme for designating the quantity of defects

Rating	Quantity of defect
0	none, i.e. no detectable defects
1	very few, i.e. small, barely significant number of defects
2	few, i.e. small but significant number of defects
3	moderate number of defects
4	considerable number of defects
5	dense pattern of defects

Table 2 : Rating scheme for designating the size of defects

Rating	Size of defect **(1)**
0	not visible under ×10 magnification
1	only visible under magnification up to ×10
2	just visible with normal corrected vision (up to 0,2 mm) **(2)**
3	clearly visible with normal corrected vision (larger than 0,2 mm up to 0,5 mm)
4	larger than 0,5 mm up to 5 mm
5	larger than 5 mm
(1) Unless otherwise specified in subsequent parts of ISO 4628. **(2)** Typically, defects larger than 0,2 mm are visible with normal corrected vision.	

Table 3 : Rating scheme for designating the intensity of changes

Rating	Intensity of change
0	unchanged, i.e. no perceptible change
1	very slight, i.e. just perceptible change
2	slight, i.e. clearly perceptible change
3	moderate, i.e. very clearly perceptible change
4	considerable, i.e. pronounced change
5	very marked change

1.3 SSPC

1.3.1 The SSPC-VIS 2 provides 27 color photographs of coated surfaces and black and white figures that show rust percentage for three types of rust distributions to which a grade is allocated scaling from 1 to 10.

1.4 ASTM

1.4.1 The ASTM provides a series of standards that are used together to allow a detailed assessment of the coating condition to be conducted. The ASTM D5065 (ASTM, 2013) describes the procedure for the assessment, while other standards provide visual guidelines to rate particular type of coating degradation as follows:

- ASTM D610 for rust breakthrough
- ASTM-D714 for blistering
- ASTM-D610 for the amount of peeling
- ASTM-D4214 for chalking
- ASTM-D660 for cracking/checking.

2 Passive fire protection

2.1 HSE qualitative categorization

2.1.1 HSE categorizes qualitatively the severity of PFP damaged condition as follows (HSE, 2007):

a) Severity Level 1 - will cause gross failure of PFP, when subjected to a fire threat, leading to a significant element of the protected component becoming exposed to the fire. Remedial action will involve removal and reinstatement of significant amounts of material and should be undertaken immediately.

   This level of damage includes:

   - Unretained and disbonded material
   - Corrosion or mill scale under an epoxy intumescent
   - Reinforcement exposed and visibly damaged
   - Substrate exposed with reinforcement damaged
   - Major failure of retention system at corners
   - Water at PFP/substrate interface
   - Waterlogged or "popped" material
   - Modification with PFP not reinstated
   - Addition of attachment with no PFP protection (absence of PFP protection at some location).

b) Severity Level 2 - provides some protection of substrate but may reduce the fire resistance performance during the fire threat to a level that is unacceptable, or is present in an area of high structural importance, or presents a falling object or integrity hazard, or will lead to significant deterioration of the material. Remedial action will involve a repair requiring reasonable levels of reinstatement within an agreed timescale.

   This includes,

   - Retained but disbonded material
   - PFP eroded with retention mesh exposed but intact
   - Surface cracks, chips, gouges, scrapes, spalling and topcoat loss with reinforcement unexposed, but found in extreme environmental locations or areas of excessive physical exposure where accelerated (area of higher likelihood of damage occurrence) damage can occur (damage occurrence is possible)
   - Any surface cracks, chips, gouges, scrapes and spalling with reinforcement unexposed but located on edge features of beams and columns.
   - Evidence of inadequate material thickness or poor reinforcement at edge features of load bearing structural elements
   - Any anomaly that is not a Level 1 anomaly but is located at a critical structural integrity location
   - Evidence of chalking through exposure to UV (Intumescent)
   - Evidence of heat damage from welded modifications or operations (Intumescent)
   - Part thickness anomalies at edge features of load bearing structural sections (Intumescent)
   - Evidence of inadequate material thickness or poor reinforcement at edge features of load bearing structural elements (Intumescent).

c) Severity Level 3 - minor damage will worsen if not repaired but does not immediately reduce the fire resistance performance. It will lead to deterioration of the material leading to 1 or 2 unless corrected. Remedial action will be minor and will be a maintenance task.

   This includes:

   - Surface cracks, chips, gouges, scrapes spalling and topcoat loss with reinforcement unexposed and located in protected environmental locations
   - Surface cracks, chips, gouges, scrapes and spalling with reinforcement unexposed but located in areas of extreme physical exposure.

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