Health and Safety Executive

Structural integrity management framework for fixed jacket structures

Prepared by **Atkins Limited**
for the Health and Safety Executive 2009

RR684
Research Report

Health and Safety
Executive

Structural integrity management framework for fixed jacket structures

Philip May
Atkins Limited
Saddlers House
Gutter Lane
London
EC2V 6BR

With many offshore installations in the UK sector of the North Sea now reaching or exceeding their original anticipated design life, there is a particular need to evaluate approaches to structural integrity management by offshore operators to ascertain their adequacy in managing aging structures. In addition to this, a significant proportion of the aging structures are now operated by duty holders who are relatively new to the UKCS, and may not be following recognised good practice for structural integrity management.

A pilot study by HSE, undertaken during 1995-1996 and the results of the KP3 audit programme have highlighted the varying approaches to structural integrity management by duty holders, in terms of both the methods used and their effectiveness.

The objective of the study presented in this document is to develop a comprehensive framework for the structural integrity management (SIM) of fixed jacket structures reflecting the Health and Safety Executive Offshore Division's technical policy. This framework is a medium for communicating what HSE regards as good industry practice and thereby to stimulate duty holders' continual performance improvement.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the author alone and do not necessarily reflect HSE policy.

HSE Books

First published 2009

TABLE OF CONTENTS

Appendices

ABBREVIATIONS AND ACRONYMS

CP	Cathodic Protection
DCR	Design and Construction Regulations
EER	Evacuation, Escape and Rescue
HSE	Health and Safety Executive
IC	Inspection Contractor
IM	Integrity Manager
IVB	Independent Verification Body
LAT	Lowest Astronomical Tide
MAH	Major Accident Hazard
NDT	Non Destructive Testing
OIM	Offshore Installation Manager
OSD	HSE Offshore Division
RAT	Rope Access Technicians
ROV	Remotely Operated Vehicle
SCE	Safety Critical Element
SCR	Safety Case Regime
SIM	Structural Integrity Management
STA	Structural Technical Authority
UKCS	UK Continental Shelf

GLOSSARY OF TERMS

Air gap:	The positive difference between the lowest point of the underside of the cellar deck and the crest height of an extreme wave for a given return period.
Audit:	Process to confirm that SIM is carried out in conformity with the procedures set out in the SIM policy and strategy, and complies with applicable legislation.
Continual improvement:	Ongoing implementation of findings of audits and reviews to improve the SIM process.
Duty holder:	In relation to production installations the operator. In relation to non-production installation the owner.
Information management:	The process by which all relevant historical and operational documents, data and information are collected, communicated, stored and made available to those who need it.
Inspection programme:	A detailed scope of work for the offshore execution of the inspection activities. It is developed from the inspection strategy.
Inspection strategy:	A systematic approach to the development of a plan for the in-service inspection of a structure.
Inspection work scope:	Instruction to the inspector to define the detailed inspection requirements.
Inspection:	Targeted examination to determine the condition of a structural component.
Life extension:	In the context of this report, life extension is the demonstration of safe operation of the structure to the end of the extended anticipated operating life (EAOL).
Maintenance:	The upkeep of the condition of a structure or component by proactive intervention.
Performance standards:	A 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 life cycle of the installation.
Review:	Process to review how the SIM processes can be improved on the basis of in house and external experience and industry best practice.
Safety critical elements (SCEs):	Parts of an installation and its plant whose purpose is to prevent, control or mitigate major accident hazards (MAHs) and the failure of which would cause or contribute substantially to a major accident.
SIM policy:	The SIM policy sets out the overall intention and direction of the duty holder with respect to SIM and the framework for control of the SIM related processes and activities. These should be aligned with the duty holder’s strategic plan and other corporate policies.

SIM strategy:	The SIM strategy sets out the duty holder's process for delivering the integrity management of its assets, and which is consistent with the SIM Policy.
Splash zone:	LAT up to the module support frame.
Structural analysis:	Calculation to predict the behaviour of the structure usually relative to specified code requirements.
Structural assessment:	Interpretation of available information including any available analysis results to confirm or otherwise the integrity of the structure.
Structural evaluation:	Review of current 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.
Structural integrity management:	The means of ensuring that the people, systems, processes and resources that deliver integrity are in place, in use and will perform when required over the whole lifecycle of the structure.
Structural integrity:	The ability of a structure to perform its required function effectively and efficiently over a defined time period whilst protecting health, safety and the environment.
Sub-sea intervention:	Reactive reinstatement of the condition of a structure or component following an inspection.
Topsides:	Structure including and above the module support frame.
Written scheme of verification	Written schemes implemented to confirm, or otherwise, that safety critical elements are suitable and remain in good repair and condition.

1. EXECUTIVE SUMMARY

With many offshore installations in the UK sector of the North Sea now reaching or exceeding their original anticipated design life, there is a particular need to evaluate approaches to structural integrity management by offshore operators to ascertain their adequacy in managing aging structures. In addition to this, a significant proportion of the aging structures are now operated by duty holders who are relatively new to the UKCS, and may not be following recognised good practice for structural integrity management.

A pilot study by HSE, undertaken during 1995-1996 and the results of the KP3 audit programme have highlighted the varying approaches to structural integrity management by duty holders, in terms of both the methods used and their effectiveness.

The objective of the study presented in this document is to develop a comprehensive framework for the structural integrity management (SIM) of fixed jacket structures reflecting the Health and Safety Executive Offshore Division's technical policy. This framework is a medium for communicating what HSE regards as good industry practice and thereby to stimulate duty holders' continual performance improvement.

The emphasis of this document is placed on defining 'what' the duty holders need to do to follow good structural integrity management practice. Requirements and guidance are provided for all aspects of the structural integrity management process, and this includes;

- Organisation and management
- Structural integrity management policy and strategy
- Inspection strategy
- Information management
- Structural evaluation
- Sub-sea intervention
- Audit, review and continual improvement
- Documentation
- Life extension

A short section providing guidance on the implementation of the framework is provided.

This document has been developed largely on the basis of existing standards and industry published documents including ISO 19902, API RP 2SIM and PAS 55-1.

2. INTRODUCTION

With many offshore installations in the UK sector of the North Sea now reaching or exceeding their original anticipated design life, there is a particular need to evaluate approaches to structural integrity management by offshore operators to ascertain their adequacy in managing aging structures. In addition to this, a significant proportion of the aging structures are now operated by duty holders who are relatively new to the UKCS, and may not be following recognised good practice for structural integrity management.

A pilot study by HSE, undertaken during 1995-1996, has highlighted the varying approaches to structural integrity management by duty holders, in terms of both the methods used and their effectiveness. In response to this, OSD5 set-up the KP3 inspection programme [1] for structural integrity management, which was completed in 2007. The monitoring programme has continued under the guise of SIMIP (Structural Integrity Management Inspection Programme).

As part of the SIMIP programme there is a need to evaluate the adequacy of duty holder's structural integrity management strategies and regimes. This is an area that needs to be addressed by the HSE in its role as the regulator for the UKCS to ensure that the risk of structural failure is fully evaluated and properly controlled.

In the last 20 years, a significant amount of work has been done on improving structural integrity assessments and management [2]. This has provided a better insight into structural behaviour and safety margins through development of improved tools and monitoring techniques [3]. It is appropriate to review these and identify how these can be used to optimise structural integrity management.

The objective of the study presented in this document is to develop a comprehensive framework for the structural integrity management (SIM) of fixed jacket structures reflecting OSD's technical policy. The framework can be used as a benchmark against which a duty holder's management systems can be assessed under the SIMIP inspection programme for structural integrity. The framework also serves as a medium for communicating what HSE regards as good industry practice. Structural integrity management is an evolving process, and this reports places emphasis on the need for duty holders' continual improvement.

It is anticipated that this document will be used in the assessment of structural integrity related aspects of the first influx of thorough Safety Case review summaries that will begin to be sent to HSE from April 2008, which is 5 years from the date on which the latest safety cases submitted under SCR92 were accepted.

This document is intended for use by HSE inspectors and managers within the duty holder's organisation responsible for managing structural integrity of jacket structures, particularly those operators new to the UKCS. It covers structural integrity management of jacket structures only, excluding topsides, process equipment, wells, risers etc.

The emphasis of this document is placed on defining 'what' the duty holders need to do to follow good structural integrity management practice. A separate study has been carried out to collate guidance on the various techniques and technologies that support the implementation of this framework [2].

This document has been developed largely on the basis of existing standards and industry published documents including ISO 19902 [4] standard, API RP 2SIM [5] and PAS 55-1 [6].

3. OVERVIEW OF STRUCTURAL INTEGRITY MANAGEMENT

Definitions

Structural Integrity:

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

Structural Integrity Management:

The means of ensuring that the people, systems, processes and resources that deliver integrity are in place, in use and will perform when required over the whole lifecycle of the structure.

Introduction

The UKCS has been developed for oil and gas production for over 40 years, and a significant body of structural integrity management (SIM) practice has developed. This practice must now reflect the fact that many UKCS structures now exceed their originally intended operating life,

The introduction of the safety case regime in 1992 [7] and the DCR [8] replaced the certification system for SIM with risk based and goal setting activities structured around the management of SCEs. Safety critical elements (SCEs) are defined (in the SCR) as parts of an installation and its plant whose purpose is to prevent, control or mitigate major accident hazards (MAHs) and the failure of which would cause or contribute substantially to a major accident. SIM covers all parts of the structure, but an emphasis is placed on management of the integrity of SCE.

SIM activities are now monitored by verification and independent verification is an integral part of SIM systems at all levels. The role and responsibility of the independent verification body (IVB) are described in Section 4.1.

This has required a change in the way structural integrity is managed and to meet these regulatory requirements. In recent years, documents have been published which provide guidance on SIM, notably ISO 19902 and API RP 2SIM, which go some way to capture industry best practice.

3.1 REGULATORY CONTEXT

Design, installation and operation of offshore platforms are regulated by the HSE. The main regulations relating to structural integrity are:

1. HSE – Offshore Installations (Safety Case) Regulations 2005
2. HSE – Offshore Installations and Wells (Design and Construction) Regulations 1996

For information, basic information with respect to these regulations is provided below. It is the duty holder's responsibility that it complies with all aspects of the regulations.

Offshore Installations (Safety Case) Regulations 2005

- A safety case for the installation shall be prepared which includes identification of all hazards with the potential to cause a major accident. All major risks arising from these shall be adequately controlled and adequate arrangements for audit and the making of related reports should be in place.
- Each safety case will be thoroughly reviewed after a period of five years from its acceptance or as a result of a direction from HSE (regulation 13).
- A safety case should be revised to be kept up-to-date (regulation 14). Where material changes to the safety case are required the revised safety case shall be submitted to the HSE. Material changes include:

    - Modifications or repair to the structure where the changes have or may have a negative impact on safety
    - Introduction of new activities on the installation or in connection with it
    - Extension of use of the installation beyond its original design life
    - Major changes in technology
    - Decommissioning a production installation
- A record of the safety critical elements is to be made. A verification scheme is to be provided by which an Independent Verification Body (IVB) reviews the record and any reservations on this by the IVB are noted.
- The verification scheme shall be reviewed and where necessary revised or replaced by or in consultation with the IVB.

Offshore Installations and Wells (Design and Construction etc) Regulations 1996

- Regulation 7 (Operation of an installation): The duty holder shall ensure that the installation is not operated in such a way as to prejudice its integrity. This includes setting and recording appropriate limits within which it shall be operated and the environmental conditions in which it shall safely operate. This record is to be kept up-to-date and on the installation, available to any person involved in its operation. These limits include:
    - Maximum loads which may be imposed on parts of the structure
    - Environmental criteria for disconnection of external connections (e.g. gangways, marine risers)
- Regulation 8 (Maintenance of integrity): Suitable arrangements shall be in place to maintain the integrity of the installation, including:
    - Periodic assessments of its integrity, including planned maintenance and inspection of structures, periodic assessment of an installation taking account of its condition in relation to the original design expectations; assessment of damage or suspected damage. Periodic assessments should take account of current good practice, incorporate advances in knowledge and changes in risk levels. The frequency, scope and method of inspection should be sufficient to provide assurance, in conjunction with associated assessments that the integrity of the installation is being maintained.
    - Undertaking remedial work in the event of any damage or deterioration which may prejudice its integrity
- Regulation 9 (Reporting of danger): A report shall be made to HSE of evidence of a significant threat to the integrity of an installation, specifying the action taken or to be taken to avoid it. Examples of events that could lead to a report include:
    - Extreme storm loading causing damage to load bearing parts of the installation
    - Significant wave contact with any part of the installation not designed to withstand such loads
    - Excessive movements, deflections settlement etc
    - Excessive scour or settlement of the foundations

Associated documents

Performance Standards:

Performance standards are defined in the PFEER regulations [9] as:

- a statement, which can be expressed in qualitative or quantitative terms, of the performance required of a system, item of equipment, person or procedure and which is used as the basis for managing the hazard eg. planning, measuring, control or audit through the life cycle of the installation.

The PFEER regulations do not specify what performance standards should be and this is a decision for the duty holder, taking account of the circumstances on the particular installation.

The requirement for performance standards with respect to structural SCEs is not defined. It is therefore common practice for these to be in the form of high level statements regarding the required level of structural integrity without specific requirements with respects to potential hazards. This would typically include:

- Functionality
- Availability
- Reliability
- Survivability
- Dependency

In practice, current design criteria in codes and standards can provide a basis for setting performance standards.

Work has been undertaken to better define performance standards for structural SCEs, such as [10], but this has not been widely applied in the industry.

Written Scheme of Verification:

The written scheme of verification is defined in [11] as:

“Verification schemes are written schemes implemented to confirm, or otherwise, that SCEs are suitable and remain in good repair and condition.”

The Safety Case Regulations 2005 [12] specify that the written scheme of verification shall discuss the following:

- The principles to be applied by the duty holder for the installation in selecting persons:
    - to perform functions under the scheme; and
    - to keep the scheme under review.
- Arrangements for the communication of information necessary for the proper implementation, or revision, of the scheme
- The nature and frequency of examination and testing.
- Arrangements for review and revision of the scheme.
- The arrangements for the making and preservation of records showing:
    - the examination and testing carried out
    - the findings
    - remedial action recommended; and
    - remedial action performed.
- Arrangements for communication to an appropriate level in the management system of the duty holder for the installation.

Safety Case Review:

The 2005 revision to the Safety Case Regulations [12] introduced a new requirement in Regulation 13, which is for a "thorough review" of a safety case, either when directed by the HSE or within 5 years of the date when HSE last accepted the safety case or the date of the previous review. This requirement is in addition to Regulation 14 which is concerned with revision of safety cases, i.e. ensuring a safety case is up to date reflecting the current state of the installation and its operations. Revisions are required when there is a "material change", such as significant modifications or repairs to the structure or change of ownership. Extension of the use of the installation beyond its original design life is also listed as a "material change". HSE have issued Information Sheet 4/2006 [13] which provides details of what is expected of a "thorough review". This includes:

- Confirmation that the safety case is still adequate and likely to remain so until the next thorough review (i.e. for 5 years or less if a review is called for by the HSE)
- Comparison of the case against current standards, HSE guidance and industry practice for new installations. Evaluation of any deficiencies and identifying and arranging for implementation of any reasonably practicable improvements to enhance safety.
- Identification of ageing processes, design parameters and changes in operating conditions that may limit the life of the installation and safety critical plant and equipment.
- Confirmation that the management of safety is adequate

Information Sheet 4/2006 also provides some examples of good practice in undertaking a thorough review. These include checking:

- Design and operational parameters of the structure, together with actual operational experience and projected operational status and lifetime. This includes checking fatigue and corrosion life of the topsides and structure, using measured corrosion rates and measured structural loading parameters
- Maintenance, inspection and testing experience of SCEs
- Modifications to the installation or plant, including SCEs
- Changes to and behaviour of SCEs
- History of incidents and abnormal/unexpected events
- New knowledge and understanding, including findings from recent research
- Changes in safety standards or safety methodologies (e.g. publication of new codes)
- Changes in management of safety and human factor aspects, including arrangements for ensuring competence

It is stated that each review should be directed towards showing the current safety case would remain valid until the next thorough review. It is also proposed in Information Sheet 4/2006 that a team is set up to manage the "thorough review", including staff that are independent from those routinely involved in maintaining and revising the safety case.

Regulation 13 requires the duty holder to send a summary of the review to HSE within 28 days of either the date at which HSE directed the review or the date at which the review was completed.

3.2 THE SIM PROCESS

This report identifies a number of key processes that constitute good practice in SIM, together with an appropriate management and documentation structure. These 8 processes are as follows:

1. SIM Policy: The SIM policy sets out the overall intention and direction of the duty holder with respect to SIM and the framework for control of the SIM related processes and activities. These should be aligned with the duty holder's strategic plan and other corporate policies.

2. SIM Strategy: The SIM strategy sets out the duty holder’s process for delivering the integrity management of its assets in line with the SIM Policy and sets acceptance criteria.
3. Inspection Strategy: A systematic approach to the development of a plan for the in-service inspection of a structure.
4. Inspection Programme: The inspection programme is the detailed scope of work for the offshore execution of the inspection activities to determine the current condition of the structure. It is developed from the inspection strategy.
5. Structural Evaluation: Review of current 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 acceptance criteria for structural integrity are met. This process identifies any repair or maintenance requirements to meet the acceptance criteria for structural integrity.
6. Maintenance: The upkeep of the required condition of the structure by proactive intervention, based on output from the structural evaluation.
7. Information Management; The process by which all relevant historical and operational documents, data and information are collected, communicated and stored.
8. Audit and Review: Audit is the process to confirm that SIM is carried out in conformity with the procedures set out in the SIM policy and strategy, and legislation. The Review Process assesses how the SIM processes can be improved on the basis of in house and external experience and industry best practice.

The interaction between these processes within the overall SIM process is given in Figure 1. The requirements for each process have been set-out in the report sections, together with guidance on how to achieve good practice.

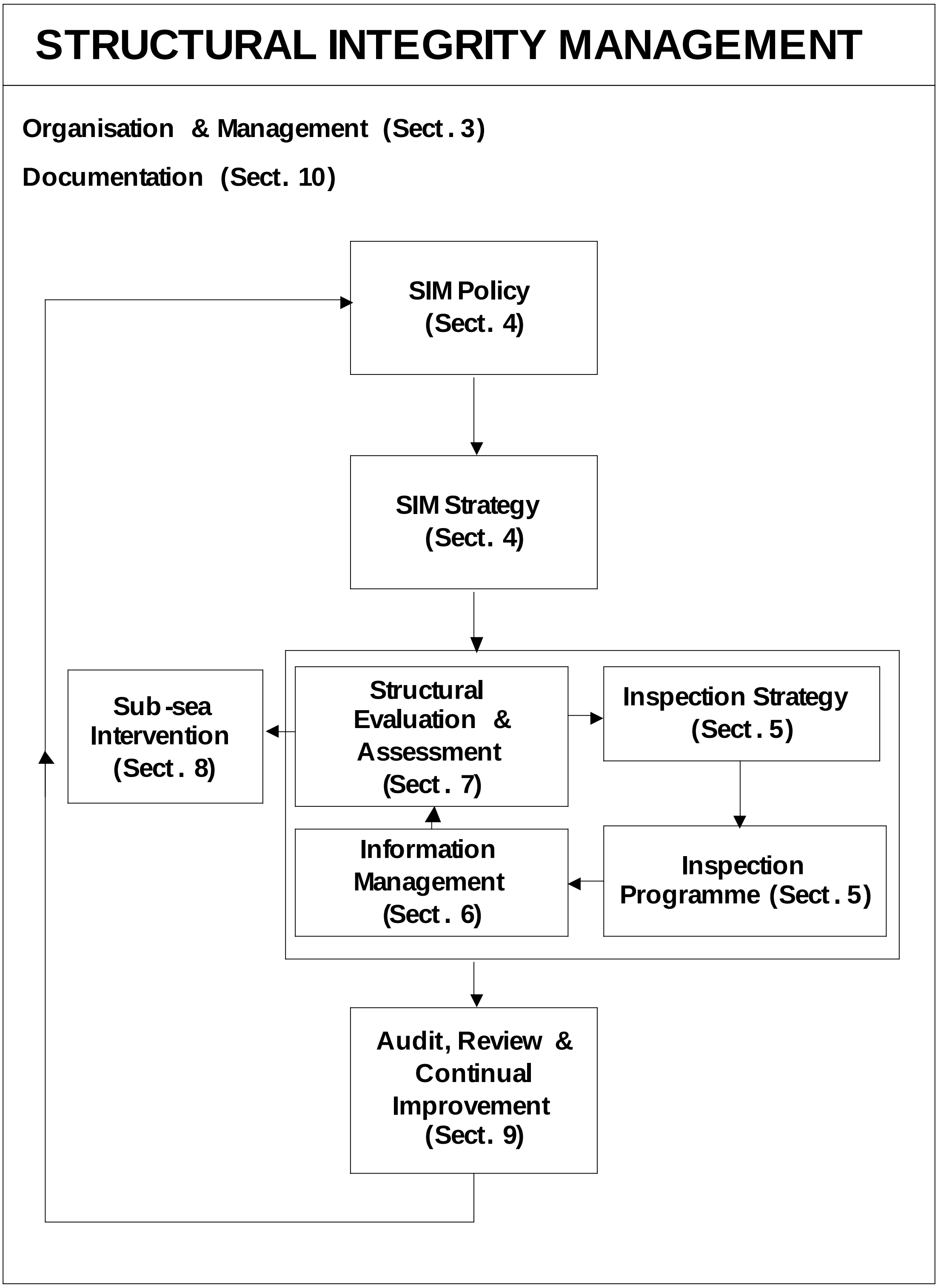


Figure 1. SIM overview flowchart

4. ORGANISATION AND MANAGEMENT

Introduction

SIM requires the duty holder to put in place an appropriate organisational structure and have defined management processes. The objective of these is to define responsibilities of individuals and to clearly set out their activities, interactions, lines of communication and interfaces. Typically, these would be recorded in the duty holder’s SIM strategy. The following aspects should be considered as a minimum:

- Management structure
- Roles and responsibilities
- SIM activities
- Competency management
- Emergency response

4.1 MANAGEMENT STRUCTURE

The duty holder should have in place a transparent and effective management structure.

The management systems should:

- clearly identify the procedure for risk assessment and acceptance
- identify technical and budgetary responsibilities. This should be an integral part of the SIM strategy and be clearly communicated so that all personnel are aware of and accept their responsibilities and reporting structure.
- identify reporting lines for all personnel
- cover the role of and management of external suppliers
- be reviewed following mergers and acquisition of any additional assets to confirm its continued suitability

Typically, the interactions and interfaces between the parties are included in the SIM strategy document in the form of a flowchart.

4.2 ROLES AND RESPONSIBILITIES

Roles and responsibilities can vary depending on the organisational set-up, complexity, number of structures and other factors. This section does not set-out firm requirements for the various roles, but provides a typical example of roles and responsibilities within a SIM process, which has been found to work in practice. The actual responsibilities for personnel may vary between organisations. However, it is the duty holder´s responsibility that a suitable organisational structure is in place.

Integrity Manager (IM)

The IM is appointed by the duty holder and is responsible for ensuring performance standards in platform safety case relating to structural integrity are met. This is typically achieved by:

- Setting the SIM policy in line with corporate policy and business plan
- Meeting the objectives set in the SIM policy
- Approving a SIM strategy in line with the SIM policy
- Ensuring the required resources are available to allow the SIM strategy to be implemented
- Appointment and management of the IVB and other parties involved in delivering SIM
- Providing access to information resources for all parties involved in SIM

- Communicating any issues which pose an immediate risk to the integrity of the platform to the OIM
- Reporting integrity risks to the operator's business management

Structural Technical Authority (STA)

The STA is responsible for developing the SIM strategy to define the processes by which the SIM objectives set-out in the SIM policy are achieved. Responsibilities of the STA typically include:

- Assessment of integrity issues and ensuring visibility of these issues and associated risks to the integrity manager
- Develop and maintain SIM strategies around SCEs and PSs
- Develop and maintain structural inspection strategies
- Develop weight control procedures and maintain a weight database
- Maintain analysis models of structure and perform structural assessments as required
- Advise IM on planned modifications
- Develop and maintain environmental load (airgap, tilt and metocean data) strategy
- Produce the annual summary report of integrity issues
- Review inspection and maintenance workscopes
- Assess inspection findings and make recommendations
- Evaluate and make recommendations for change management
- Provide structural input to any emergency response situation

Inspection Contractor (IC)

The IC supplies personnel and resources to carry out routine survey and inspection of the structure. The IC is typically a specialist contractor, with its own inspection and quality procedures, which will need to be reviewed for consistency with SIM documentation e.g. the contractor's response to a reported flooded jacket member will normally be recorded in the inspection procedures. It is important to ensure this response is adequate. Responsibilities of the IC typically include:

- Generation of detailed inspection work scopes in line with the requirements set out in the structural inspection strategy
- Ensuring competency and qualifications of inspection personnel
- Carrying out inspections in line with the work scopes
- Providing detailed reporting on inspection findings

Independent verification body (IVB)

With the introduction of the Safety Case regime and DCR regulations, the certification system for SIM was replaced by risk based and goal setting activities with independent verification. The IVB reports to the duty holder to provide assurance that the SIM system is adequate. The role of the IVB is specified in [8] and forms part of the whole lifecycle of the platform SIM process.

The responsibility of the IVB is to verify that the Performance Standards for structural SCEs have been met in accordance with the Written Scheme of Verification, which is normally produced by the IVB in agreement with the duty holder. Aspects that would typically be covered by the IVB include:

- Review of any impairments or maintenance issues with respect to SCEs

- Verification of any significant structural modifications
- Verification of the SIM processes

The IVB should be involved with general SIM related activities such as analysis reviews and modification reviews, and have free access to any relevant information and the remit and resources to carry out their duties as required by the DCR regulations. The IVB should be informed of any significant structural issues and should be given the opportunity to provide comments.

The findings of the KP3 Asset Integrity Programme carried out by HSE between 2004 and 2007 [12] identified that the involvement of the ICP is often limited in practice.

Offshore Installation Manager (OIM)

As the person responsible for safe operation of the offshore platform, the OIM will have a strong interest in SIM and will work closely with the IM and others to facilitate the delivery of SIM.

All personnel working on SIM have a duty to report to the OIM any issues that pose an immediate risk to the integrity of the platform.

4.3 COMPETENCY MANAGEMENT

The duty holder is responsible for SIM, which includes competency of its own personnel and a duty of care with respect to the competency of external contractors. It is therefore required that the duty holder acts as an intelligent customer when purchasing services from external contractors.

Competence of personnel relates to the relevance of their education, training and experience to carry out their role within the SIM process. The level and area of competence differs between roles.

Guidance is provided in ISO 19902, Section 24.8 and API RP 2SIM, Section 1.5 on the topic of competence management for SIM. The engineer or group of engineers involved with SIM should be:

- familiar with relevant information about the specific platform(s) under consideration
- knowledgeable about underwater corrosion process and prevention
- experienced in offshore structural engineering
- awareness of the difference between design and assessment engineering
- experienced in offshore inspection planning
- knowledgeable and certified where appropriate in the use of inspection tools and techniques
- aware of general inspection issues in the offshore industry e.g. UKOOA and HSE safety alerts

Details on specific requirements for evaluation and inspection, data collection and update and inspection programme are given in ISO 19902.

Competency management can be aided by putting in place a suitable policy for recruitment, retention and succession planning of duty holder staff and any contractor staff to provide continuity of personnel. This provides some clear technical benefits, but also encourages development of a safety focused culture.

In many instances, competency management extends to external suppliers who may have a direct effect on SIM.

4.4 EMERGENCY RESPONSE

Any SIM process should consider preparedness for emergencies and this should be documented as part of the SIM strategy. The process should closely interface with operator’s primary Evacuation, Escape and Rescue (EER) plan.

The emergency response process should set out the means in which relevant parties are alerted in the case of an emergency situation. This should include out-of-office hours contacts. Typically, the following personnel should be included as a minimum:

- Integrity manager
- Offshore installation manager
- Structural technical authority

The emergency response process should demonstrate that rapid access to all integrity information, assessment software, resources is available to the named personnel.

5. STRUCTURAL INTEGRITY MANAGEMENT POLICY AND STRATEGY

Definitions:

SIM Policy: The SIM policy sets out the overall intention and direction of the duty holder with respect to SIM and the framework for control of the SIM related processes and activities. These should be aligned with the duty holder's strategic plan and other corporate policies.

SIM Strategy: The SIM strategy sets out the duty holder's process for delivering the integrity management of its assets, and which is consistent with the SIM Policy.

Introduction:

The SIM policy and strategy generally cover all aspects of structural integrity management for a fleet of assets operated by the duty holder. This would typically include:

- Sub-sea inspection
- Topsides inspection
- Appurtenance inspection
- Weight control
- Airgap and settlement monitoring

The framework put forward in this document covers the structural integrity of steel jacket structures only. However, the SIM policy and strategies should be developed for the overall fleet of structures and should apply to sub-sea as well as topside structures.

The HSE's objective for the strategy for structural integrity given in [14] is "to secure the life-cycle structural integrity of offshore installations in order to safeguard those working offshore".

5.1 SIM POLICY

The duty holder should have a SIM policy which is endorsed at senior management level.

The objectives of the SIM policy are:

- to define the overall intentions and direction of the organisation with respect to SIM
- to integrate and align SIM with the overall business plan and other corporate policies
- to set out a framework for SIM

The policy should:

a. include a commitment to comply with current applicable legislation, regulatory and statutory requirements and to other relevant industrial and national standards and practices.

b. be reviewed periodically and be committed to continual improvement of the SIM process.

c. be documented and effectively communicated to all relevant parties including employees and contractors.

5.2 SIM STRATEGY

The duty holder's STA should develop a SIM strategy that is authorised by the integrity manager.

The objective of the SIM strategy is:

- to implement the SIM policy

Guidance on setting a SIM strategy is given in ISO 19902 and API RP 2SIM.

The strategy should:

a. include a description of the assets included in the strategy, including their function(s) and performance and condition requirements. This should include health, safety and environmental performance requirements.

b. identify roles and responsibilities in delivering SIM. Roles to be covered may include:

    - Integrity manager
    - Offshore installation manager
    - Structural technical authority
    - Sub-sea inspection contractor
    - Engineering services contractor
    - Independent verification body

c. include reference to all SCEs and their performance standards which are identified in the Safety Case and associated documents

d. define the process and rationale involved in delivering SIM, ensuring best use is made of all information available. This could include:

    - Sub-sea inspection specification
    - Anomaly evaluation and management
    - Inspection data management and reporting
    - Weight control
    - Structural analysis models and assessments
    - Metocean data and airgap measurement
    - Management of change with respect to structural integrity
    - Systems and tools and processes for managing data and information about the structure and its appurtenance including inspection results, assessment results, work performed, backlog of work, costs, etc.

    These process should be appropriate to the importance and the condition of the components involved and risks to structural integrity of these components.

e. include reference to the emergency response strategy

f. include processes for monitoring the performance of the structures and of the management systems used, benchmarking, management review and corrective actions

g. include arrangements to capture lessons from in-service performance of structures and feed this back into the management arrangements to seek continual improvement

h. include references to processes for audit and assurance arrangements, including independent verification of SCEs

i. be reviewed periodically to ensure current best practice and emerging technologies are utilised and should be revised when required

6. INSPECTION STRATEGY

Definitions:

Inspection:	Targeted examination to determine the condition of a structural component.
Inspection Strategy:	A systematic approach to the development of a plan for the in-service inspection of a structure.
Inspection Programme:	A detailed scope of work for the offshore execution of the inspection activities. It is developed from the inspection strategy.
Inspection work scope:	Instruction to the inspector to define the detailed inspection requirements

Introduction:

The sub-sea inspection strategy is a document prepared by the STA, specifying the inspection methods and intervals. It is used by the inspection contractor to prepare detailed inspection programme. This contains work scopes which are used by the individual inspectors to define their tasks.

The sub-sea inspection strategy typically covers the structural components below LAT. The structure between LAT and the module support frame is in the splash zone, but forms part of the jacket structure. This part of the jacket is typically covered in the topsides inspection strategy and inspection would generally be carried out by RAT inspectors.

6.1 SUB-SEA INSPECTION STRATEGY

The duty holder should develop and maintain a subsea inspection strategy.

The objectives of a sub-sea inspection strategy are to:

- ensure that structural integrity is maintained
- ensure that safety of offshore personnel is safeguarded
- ensure the environment is not impaired

The inspection strategy should:

a. be consistent with the structural integrity strategy and SIM processes including structural evaluation, assessment, maintenance and information management requirements

b. as a minimum determine with reasonable level of confidence the existence and extent of deterioration, defects and damage

c. address the motives for inspection listed by ISO 19902 (as repeated below for information)

d. be developed and maintained by a competent person, using appropriate experience, data and where required analysis

e. specify the tools and techniques to be used

f. be documented

Guidance

Guidance is available in ISO 19902. The main headings on this topic in ISO 19902 are:

- Inspection strategy (section 24.4)
- Inspection programme (section 24.5)
- Inspection requirements (section 24.6)
- Default periodic inspection requirements (section 24.7)

Although Section 24.7 outlines default periodic inspection requirements, these are generic and would need to be carefully reviewed and customised before this would be suitable for any platform on the UKCS. API RP 2SIM provides guidance on the use of alternative risk-based inspection strategies.

ISO 19902 gives the following motives for in-service inspection:

- Detection of degradation or deterioration
- Detection of fabrication defects or installation damage
- Detection of damage due to design uncertainties or errors
- Detection of damage due to environmental overload
- Detection of damage due to accidental events
- Changes in permanent loading
- Monitoring of known defects or repair effectiveness
- Change of ownership
- Statutory requirements
- Reuse of a structure

A sub-sea inspection strategy would normally be expected to contain the following sections:

1. Platform or fleet description

   Typically this would include the structural configuration, age, location, function, platform manning levels etc.

2. Scope

   Usually includes structural elements below water level including J-tubes and conductors. Pressure boundaries such as risers are excluded from the scope. It is normal practice to include the supports / connection to the structure.

3. Roles and responsibilities

   More detail on the roles and responsibilities is provided in Section 4.1.

4. Inspection documentation and reporting

   Typically includes detailed statement on:

   - Data recording
   - Data reporting process
   - Databases used
   - Daily progress reporting for dive and ROV inspections
   - Inspection reporting

5. Inspection methods

   Normally includes:

- General Visual Inspection (GVI)
  to verify the overall integrity of specified members or components. The main objective is to confirm that the member is present and to check for gross defects, deformation or damage. Requires no prior cleaning of the member and is usually carried out by ROV. Video logs are usually provided.
- Close Visual Inspection (CVI)
  to determine more accurately the condition of a member or component and to check for local defects or damage. Cleaning of marine growth is generally required. Usually carried out by divers. Still images of anomalies are usually provided.
- Flooded Member Detection (FMD)
  to check tubular members for through wall defects. Usually deployed by ROV.
- Weld NDT (Non Destructive Testing)
  to look for specific degradation mechanisms such as wall thinning and cracking. A number of methods are available including:
  - Ultrasonic wall thickness measurements
  - Magnetic Particle Inspection (MPI) for surface breaking defects (requires coating removal)
  - Eddy Current Detection (ECD) screening method for surface breaking defects (usually does not require coating removal)
  - Ultrasonic Testing (UT) for surface breaking and embedded defects (usually requires coating removal)
  - Alternating Current Field Method (ACFM) for surface breaking defects (usually does not require coating removal)
  - Other specialist techniques should be considered. Examples include:
    - Time of Flight Diffraction (TOFD)
    - Long Range UT
    - Phased Array UT
- Cathodic Protection (CP) survey
  to confirm that the electrical potential of the CP system is sufficient to protect the structure. This is typically in the range of -850mV to -1100mV. Guidance is given in ISO 19902
- Marine growth survey
  to monitor the thickness of any marine growth present. Guidance is given in [15]
- Scour survey
  this is normally done by ROV.
- Debris survey
  to identify any debris on the structure or on the sea bed in the vicinity. Guides for conductors and caissons should be checked. Usually carried out by ROV
- Bolt tension survey
  for clamps and other connections to ensure pre-load is maintained
- Caisson and conductor survey
  This includes the supports for these items affect the integrity of the structure. Often, for efficiency the actual component is GVI/CVI inspected at the same time even though it is not part of the structure.
- Structural monitoring
  There is a range of continuous monitoring techniques which should be considered as a

complementary technique to standard inspection techniques. Details are given in [3]. Typical techniques include:

- Strain monitoring
- Dynamic response monitoring
- Acoustic emissions (AE)

6. Inspection requirements

   The inspection requirements for each component or family of components covered by the strategy should be included. The inspection requirements consist of the inspection type, extent and interval, and should include any specific requirements.

   The inspection requirements must be consistent with the SIM strategy in place for the platform, taking into account:

   - Component characteristics
   - Component condition
   - Component criticality i.e. consequence of failure
   - Potential failure modes
   - Operating experience and historic failure rates
   - Any analysis / assessment results available
   - Comparison of performance of similar components
   - Fleet assessments – platform risk assessment in comparison with others in fleet

   and this should be documented as part of the sub-sea inspection strategy.

7. Review and improvement

   The sub-sea inspection strategy should include a statement on the need for review and improvement. This should take into consideration structural modifications, changes in the platform condition or consequence of failure. It should also consider failure trends across different platforms and the industry.

   The review should also take into account the development of existing and new inspection and monitoring methods and should periodically confirm that the most appropriate techniques are used.

6.2 SPLASH ZONE

Inspection requirements for the splash zone (LAT up to the module support frame) are typically covered in the topsides inspection strategy. Although the inspection techniques available for this area are different from the sub-sea inspection techniques, the general process to arrive at suitable inspection requirements for structural elements is the same as that for sub-sea elements as described above.

Structural failure modes and degradation mechanisms which are of particular concern for members in the splash zone, and which may require focused inspection, include:

- Impact damage from ships, debris and dropped objects
- Paint system breakdown and corrosion
- Fatigue failure of jacket members and appurtenances due to exposure to wave loading
- Protective devices such as riser guards
- Condition of riser and caisson supports
- Escape to sea arrangements

6.3 INSPECTION PROGRAMME

The inspection programme is developed from the inspection strategy. It also requires schedules, budgets, personnel profiles, inspection procedures for implementation.

Guidance on developing an inspection programme is given in ISO 19902, Section 24.5 and API RP 2SIM, Section 5.

7. INFORMATION MANAGEMENT

Definitions:

Information Management: The process by which all relevant historical and operational documents, data and information are collected, communicated, stored and made available to those who need it.

Introduction

Structural integrity management has the potential to produce large amounts of information, which needs to be collected, communicated and stored in an efficient and accessible manner. Ease of information access, clarity in presentation, information interrogation, trending and others are aspects of data management that have a pronounced effect on the overall effectiveness and efficiency of SIM.

To this effect duty holders typically have computerised systems in place. As with any database system, the reliability and accuracy of the data stored is largely dependent on the quality and format of the data input in the system.

Requirements

The duty holder should ensure that:

a. information is established and maintained, in a suitable form, which describes the key elements of the SIM system and their interaction and also provides direction to related documentation.

b. records of the following items are retained for the duration of the platform life and transferred to new owners as necessary:

   - General platform characteristic data, e.g. original or subsequent owners, original or subsequent function, location and orientation, water depth, corrosion protection systems etc.
   - Original design analyses, e.g. design contractor, date of design, design drawings, material specifications, design codes used, environmental criteria etc.
   - Structural assessments, including computerised numerical models of the structure
   - Fabrication details, including as-built drawings
   - Transportation details
   - Installation reports
   - In-service maintenance
   - Engineering evaluations
   - In-service inspection condition monitoring including current condition and presence of anomalies including photographic records
   - Repairs and structural modifications
   - Mitigating actions
   - Records of accidents and incidents

c. historical information on the topics in b. should be retained. Additionally, the duty holder should endeavour to identify and recover any relevant information not directly held by the duty holder, such as that held by the Certifying Authority under the certification regime.

d. the following databases should be kept as a minimum:

- As built drawings
- Current and historic inspection results
- Maintenance activities and modifications
- Drawing register (not required if the drawing database is suitably searchable)
- Environmental data

The following databases are recommended in addition to those listed in d.:

- anomalies register, including criticality rating.
- damage register.
- completed and outstanding inspections.

e. control procedures are in place to ensure that:

    - documents, data and information are easily locatable and accessible to authorised personnel.
    - documents, data and information are periodically revised to incorporate any changes.
    - current versions of relevant documents data and information are available at all sites where asset related tasks are performed.
    - obsolete documents, data and information are promptly removed from all points of use, and substituted by their replacement document.
    - archival documents, data and information retained for legal or knowledge preservation purposes are suitably identified.
    - documents, data and information are suitably secure dependent on the level of sensitivity involved, and if in electronic form are adequately backed up and can be recovered.
    - any data which has become obsolete is removed, archived or flagged as 'obsolete' to avoid cluttering the data base.

f. data should be stored in such a way as to aid trend spotting where possible. This is of particular value for inspection data which can be used to establish trends between consecutive inspections, and between assets. Advanced trend spotting techniques such as fuzzy logic can help ensure that data use is optimised.

g. inspection data should be stored in a way which readily allows interrogation of critical anomalies

h. inspection and maintenance data should be stored in a way which readily allows collation of information on any backlog of inspection / maintenance activities

i. remote access of platform and off-site staff is available

8. STRUCTURAL EVALUATION

Definitions:

Structural Evaluation:	Review of current 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.
Structural Analysis:	Calculation to predict the behaviour of the structure usually relative to specified code requirements.
Structural Assessment:	Interpretation of available information including any available analysis results to confirm or otherwise the integrity of the structure.

Introduction

Structural evaluation is the ongoing process to confirm that the basis for demonstrating the structural integrity and associated risk levels are still valid. Any significant changes need to be captured and the evaluation should determine whether the structure is required to be (re-)assessed.

8.1 STRUCTURAL EVALUATION

The duty holder should ensure that an ongoing structural evaluation is carried out. The structural evaluation process should include the following stages:

a. Maintain good visibility of current member utilisation factors and fatigue lives. This could be achieved by maintaining representative service models.

b. Review and evaluate latest inspection data to identify any significant changes, degradation or damage

c. The duty holder should ask the question "which other reasons are there to believe that any parameter that affects structural integrity has changed?"

d. Carry out structural (re-)assessment if required. ISO 19902 states the following:

"An existing structure shall be assessed to demonstrate its fitness-for-purpose if one or more of the following conditions a) or b) exist:

a) Changes from the original design or previous assessment basis

Such changes include:

1) addition of personnel or facilities such that the platform exposure level is changed to a more onerous level;

2) modification to the facilities, such that the magnitude or disposition of the permanent, variable or environmental actions on a structure are more onerous;

3) more onerous environmental conditions and/or criteria;

4) more onerous component or foundation resistance data and /or criteria;

5) physical changes to the structure's design basis, e.g. excessive scour or subsidence;

6) inadequate deck height, such that waves associated with previous or new criteria will impact the deck, and

provided such action was not previously considered;

7) extending the original design service life.

b) Damage or deterioration of a primary structural component

Minor structural damage may be accepted on the basis of appropriate local analysis without performing an assessment. However, cumulative effects of multiple damage shall be documented and included in an assessment"

e. Define mitigating actions to ensure short term and long term fitness-for-purpose. This could include:

- damage repair
- member strengthening (e.g. clamped sleeve, grouting, welded reinforcements)
- provision of alternative load path (e.g. structural clamp)
- revise inspection / monitoring requirements
- change of consequence for example by stipulating platform de-manning and emergency response procedure

f. Update the structural risk assessment in view of any findings. The risk assessment should consider the probability of an event and all its consequences and should include:

- Vessel (ship) collisions
- Change of use
- Corrosion and materials degradation
- Extreme environmental conditions
- Dropped objects
- Geotechnical hazards
- Fires and explosions
- Interaction with other risks and the cumulative risk associated with a number of smaller risks should be considered as part of this process.

The results of these assessments, and the effects of the subsequent control measures, should be considered and where appropriate provide input into:

- The SIM strategy.
- Inspection and maintenance regimes.
- The determination of requirements for the design, specification, procurement, construction, installation, commissioning, monitoring, refurbishment, replacement, decommissioning and disposal risks of structural elements.
- Identification of adequate resources including staffing levels, training needs and skills.
- Development of operational controls.
- The duty holder's overall risk management framework.

The duty holder's approach to risk identification and assessment should:

- be defined such that it is proactive rather than reactive.
- include where appropriate, an assessment of how risks change with time.
- provide for the classification of risks and identification of those that are to be avoided, eliminated or controlled by structural management objectives, targets and plans.

- be consistent with the duty holder’s operating experience and capabilities of the risk control measures employed.

8.2 STRUCTURAL ASSESSMENT

Where a structural (re-)assessment is required, this should include:

a. Assessment of risk to structural integrity on the basis of available data, including:
    - Current risk assessment
    - Relevant information from previous assessments,
    - Remedial works,
    - Operating experience and
    - Design, fabrication and installation data.

b. Identification of relevant failure modes which may include:
    - Static strength and overload
    - Fatigue and fracture
    - Buckling
    - Bolt loosening
    - Grout deterioration
    - Foundation failure
    - Negative air gap
    - Fire and explosion

c. Current loading data, including metocean data and marine growth

d. Obtaining inspection results which establish the condition of all structural elements of concern. Sufficient extent and quality of information should be gathered to allow an appropriate engineering assessment to be completed in line with the chosen assessment route. This could range from general visual inspection to detailed NDT measurements.

e. Carrying out an analysis appropriate to the risk associated with the component under consideration and the relevant failure mode(s). For example:
    - Engineering judgement may be used to demonstrate the component is fit-for-purpose. This would generally form part of any structural assessment but in isolation this would only be considered appropriate for low risk components.
    - Use of results from a previous analysis, for example by linear scaling of loads and stress levels as appropriate.
    - Comparison with the assessment results of comparable structures. It would be necessary to demonstrate the similarity in all relevant aspects.
    - Carry out simple design level calculations, typically consisting of a linear analysis of the structure.
    - Carry out non-linear analysis to determine ultimate strength, typically a nonlinear push-over analysis.
    - Carry out detailed analysis on particular failure modes, such as those mentioned above. Typical analysis could include shell models, fatigue calculations, local buckling calculations, soil structure interaction calculation etc.

The analysis may be based on deterministic or probabilistic calculations or a combination thereof, and should be based on the latest editions of the codes and standards used.

f. Interpretation of the analysis results taking into account acceptable margins and risk levels. This should include interaction with any other failure modes which may not have been considered in the analysis. An example would be the interaction between local corrosion and bucking strength of a compression member.

8.3 RELEVANT REFERENCE MATERIAL

Reference material relevant to structural evaluation and assessment is provided in Appendix B.

9. SUB-SEA INTERVENTION

Definitions

Maintenance:	The upkeep of the condition of a structure or component by proactive intervention.
Sub-sea intervention:	Reactive reinstatement of the condition of a structure or component following an inspection.

Introduction

Sub-sea intervention is typically reactive only, in response to a particular inspection finding but may also include strengthening of the platform. Regular planned maintenance is not normally required due to low corrosion rates or practicable due to difficulty of access. Therefore, maintenance of sub-sea structure is usually limited.

9.1 SUB-SEA INTERVENTION

The DCR regulations require that the duty holder shall maintain the condition of the structure to ensure it is fit for purpose.

The objectives sub-sea intervention are to:

- ensure that structural integrity is maintained
- ensure that safety of offshore personnel is safeguarded
- ensure the environment is not impaired

Common forms of sub-sea interventions include:

- Weld repair
  Welding and / or grinding or drilling to repair or remove reported cracks or retard crack growth
- Clamp installation
  To reinstate structural strength where welded repairs are not appropriate or practical
- Retro fitting of sacrificial anodes
  To reinstate and prolong life of CP system
- Marine growth cleaning
  Carried out to reduce local and global load on the structure due to increased drag. This helps improve fatigue lives and in extreme cases also reduces the risk of overload of the structure.
- Rock dumping
  Prevention and backfill of scour around structure, typically around platform legs. May be used to improve support of subsea pipelines
- Electrical continuity bonding
  To include isolated steel piles, conductors or caissons in the CP protection envelope
- Debris removal
  Typically required for safety reasons when dive operations are carried out

9.2 SPLASH ZONE MAINTENANCE

Accelerated corrosion rates and exposure to impact damage dictate that structures in the splash zone require planned inspection and maintenance activities.

Maintenance activities that one would expect to be included are:

- Coating repair and reinstatement
  It is difficult to achieve good coating in the splash zone, but paint systems are continually improving and this option is now more practicable than some years ago.
- Conductor, caisson clamp and guide maintenance
- Minor repairs due to impact damage
  These could include grouting or installation of clamps.
- Reinstatement of splash zone access walkways, ladders and stairways.

10. AUDIT, REVIEW AND CONTINUAL IMPROVEMENT

Definitions

Audit: Process to confirm that SIM is carried out in conformity with the procedures set out in the SIM policy and strategy, and complies with applicable legislation.

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

Continual improvement: Ongoing implementation of findings of audits and reviews to improve the SIM process.

Introduction

Audit and review are an integral part of the SIM loop as indicated in Figure 1. These are the processes whereby the duty holder interrogates their SIM process to ensure that operations are taking place as intended, and that these continue to be effective and appropriate. These processes consist largely of interviewing personnel and review of records. To this effect, the following sections include questions that duty holders should be considering as part of their internal audit and review processes.

10.1 AUDIT

The duty holder should have in place and maintain a SIM audit programme. The audit programme should:

a. determine whether or not the SIM processes:
   - are effective in meeting the SIM policy and strategy objectives
   - are effective in meeting all the duty holders legal obligations with respect to SIM
   - effectively manage structural integrity risks
   - have been properly implemented, maintained and recorded

b. review the results of previous audits and the action taken to rectify non-conformances

c. provide information on the results of the audits to senior management

The audit programme should be based on the results of risk assessment of the SIM processes, in-service incidents or unexpected structural performance and the results of previous audits and reviews. Particular attention should be given to new or modified systems which have been implemented during the last review period.

Where possible, audits should be conducted by personnel (internal or external) who are independent of those having direct responsibility for the activity being examined.

10.2 REVIEW

The duty holder should have in place a review process

The objective of the review process is:

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

The review should:

a. address findings from the audit programme

b. include acquisition of knowledge on new SIM techniques and technologies (including for example inspection techniques, analysis tools, risk assessment methods and monitoring methods) and practices and these should be evaluated to establish their potential benefit to SIM processes.

c. address the possible need for changes to SIM policy and strategy and SIM processes to ensure its continuing suitability, adequacy and effectiveness.

This review should be independent from the thorough safety case review required by the Safety Case Regulations 2005, Regulation 13, as described in Section 3.1.

10.3 CONTINUAL IMPROVEMENT

Continual improvement relates to the ongoing implementation of findings of audits and SIM reviews. In turn, continual improvement should be an integral part of the audit programme, thereby confirming or otherwise the effectiveness of the improvements.

10.4 INDEPENDENT VERIFICATION

Following the introduction of the DCR 1996 regulations, independent verification is now an integral part of the SIM process at all levels, and across the activities. The responsibilities of the IVB are set-out in Section 4.2.

11. DOCUMENTATION

Introduction

Under the Safety Case and DCR regulations, a number of documents need to be produced and maintained, and these are subject to periodic review by the regulator.

Requirements

The duty holder should:

a. produce and maintain the following documentation required for effective sub-sea integrity management:

  - Platform specific safety case
  - Platform specific performance standards
  - SIM policy
  - SIM strategy
  - Inspection strategy
  - Inspection programme
  - Weight control documentation
  - Inspection summary report
  - Annual summary report
  - Structural assessment models
  - Structural drawings
  - Performance monitoring reports

b. maintain appropriate document control procedures

c. ensure that all documentation is legible, readily retrievable and protected against damage, deterioration or loss.

d. establish and record document retention times.

e. ensure that records are be maintained appropriate to the SIM process and to the organisation or to meet legislative and regulatory requirements

f. ensure that all documentation fits within a clear framework and that the interconnection between documents is clear. This can be achieved by including a documentation section in high level documents such as the SIM and inspection strategy.

g. ensure that documentation is made readily available to the relevant parties.

12. LIFE EXTENSION

Definitions:

Life extension: In the context of this report, life extension is the demonstration of safe operation of the structure to the end of the extended anticipated operating life (EAOL).

Introduction

With many platforms in the UK continental shelf now approaching or exceeding their intended design life, life extension has become a prominent part of SIM.

Specific requirements for long term safety reviews (LTSR) related to life extension are discussed below, which fall outside the normal SIM process. The findings of any LTSR should be fully incorporated into the SIM process.

Guidance

Requirements for life extension and guidance on the associated process for demonstrating structural integrity for extended life is given in [16] and this is referred to here for completion. A process for demonstrating structural integrity is given in [16] as follows:

"

1 To define the calendar year for the end of the Anticipated Operating Life (AOL) of the installation. Initially this can be based on the notional design life as defined at the design stage; where this information is not available it can be taken as 20 years from the date of commissioning offshore. To determine the target Extended Anticipated Operating Life (EAOL) for the installation based on field life and other economic and operational considerations.

2 When the remaining anticipated operating life is less than or equal to the period to the next renewal of the safety case (SC), to undertake a long term safety review (LTSR) to confirm the continued integrity of the structural safety critical elements (SCEs) to the end of EAOL of the installation.

3 To include in the LTSR:

   a. Identification and evaluation of all hazards and threats to the structural integrity of the SCEs relevant to extended life.

   b. Establishment of the current configuration, material properties and physical condition of the structural SCEs through past records, testing and inspection as appropriate for the needs of the LTSR.

   c. A full structural assessment of all structural SCEs taking full account of identified hazards including ageing effects such as fatigue, corrosion, scour, subsidence etc. Information from previous assessments and verification reviews should be utilised in planning the assessment process. The assessment should be based on best available scientific and technical knowledge and information, including checking against modern codes and standards.

   d. A redundancy analysis to demonstrate that in the event of reasonably foreseeable damage to the installation sufficient structural integrity is retained to enable action to be taken to safeguard the health and safety of persons on or near it as required by DCR regulation 5(1).

   e. Revision of the Structural Integrity Management (SIM) plan in light of the results of LTSR to ensure continued integrity of the installation during the EAOL as required by regulation 8 of DCR.

4 Where the LTSR identifies any shortfall in long term integrity of the SCEs, to implement improvements as far as reasonably practicable to maintain the integrity of the installation to the end of its EAOL, as defined in regulation 8 of the DCR.

5 To implement any appropriate mitigation measures required to reduce residual risks to life to as low as reasonably practicable (e.g. online monitoring).

6 To confirm or revise the target operating life as a result of the LTSR, and to identify a date at which point the next LTSR will be needed if further life extension is required.

7 To continue to manage the structural integrity of the installation in accordance with the revised SIM plan until the end of operation or when a further life extension is required.

“

The overall process for meeting the structural integrity requirements for life extension is shown in Appendix C.

13. IMPLEMENTATION OF INTEGRITY MANAGEMENT FRAMEWORK

Introduction

The purpose of this section is to assist with the implementation of the SIM framework presented in this document. This is achieved by providing an example process that can be used to implement good practice by identifying the current gaps in SIM practice (i.e. the difference between current practice and practice recommended in this framework), prioritise the needs, assess resource needs and costs, and managing their implementation.

The process, as presented, does not suggest timescales or advocate a specific order of implementation. It is the responsibility of the duty holder to identify an appropriate implementation timeframe and the specific order in which to implement SIM practice.

Guidance

The process for implementation of good practice could consist of the following activities:

1. Identify current practice: In order to aid the gap analysis, current practice should be identified in line with the processes, requirements and guidance provided in this document. Identification of current practice should be carried out in a structured manner and be documented.
   A rating system could be used to assess the maturity of the current practice with respect to individual activities. An example of ratings that could be used in this assessment is given in Table 1. below.
2. Identify good SIM practice: The good SIM practice is provided in this document.
3. Gap analysis: The objective of the gap analysis is to identify discrepancies between current practice and good practice, and prioritise where improvements are required.
4. Develop implementation plan: The implementation plan should be based on the Gap analysis, taking into consideration realistic budgets, timescales, resources and time constraints. The implementation plan should include the following:
   - Programme
   - Documented gap analysis
   - Identification of resources
   - Budget requirements

   The implementation plan should be fully documented and provide appropriate rationale for any departures from good practice.
5. Delivery of implantation plan: The implementation plan should be delivered as a formal project.
6. Monitor and feedback: The effectiveness of the implementation plan should be reviewed periodically and the implementation plan adjusted if required.

The relation between these activities is shown in Figure 2 below.

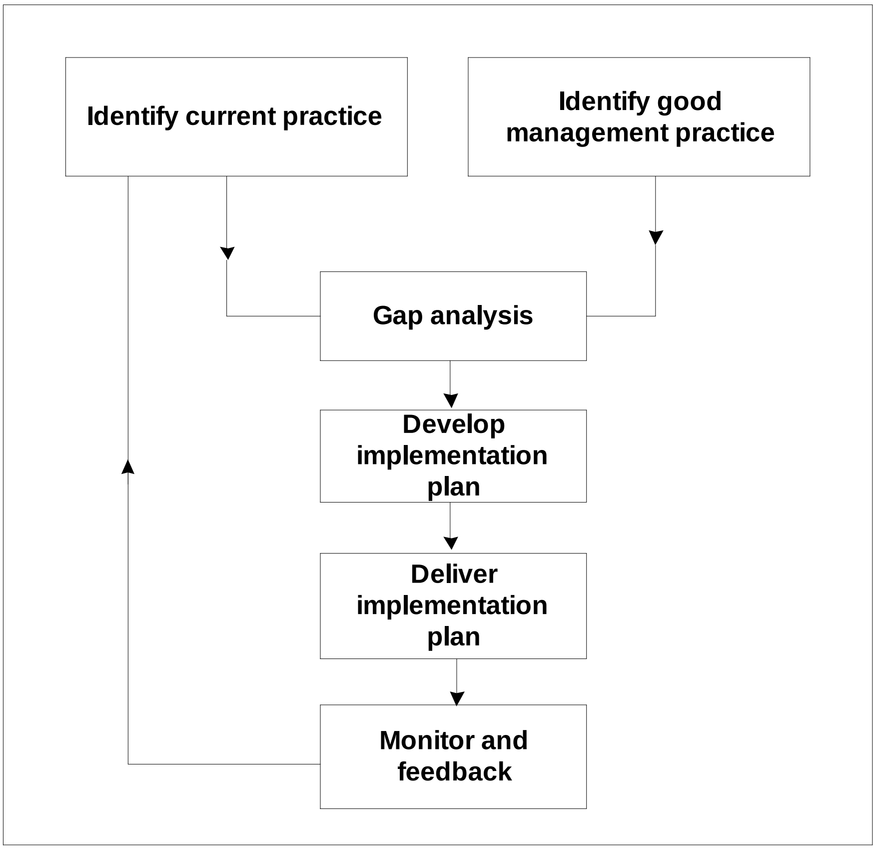


Figure 2. Best practice implementation flowchart

Table 1. Example rating system for assessment of current SIM activities

Rating	*Processes*	*Information and documentation*	*Organisation*	*Personnel*
1	Not in place – The need has not been recognised or the need has been recognised but no action has been taken.	Poor – quality and quantify are below the level required to undertake basic SIM activities.	Poor – structure not suitable for adequate SIM. Roles and responsibilities not appropriately defined.	Unsatisfactory – competence below minimum requirements in many areas and/or sever staff shortages.
2	Implementation – the need has been recognised and a plan for implementation is currently being developed or is already being implemented	Basic – inventory is adequate but quality is poor.	Needs improvement – Roles and responsibilities appropriately defined but not clearly communicated.	Needs improvement – staff competence below minimum requirements in some areas and/or some staff shortage.
3	Recently implemented – has recently been implemented and the user is in the early stages of training and usage.	Fair – inventory is complete and quality sufficient to support basic SIM activities.	Fair – Appropriate organisational structure in place and all responsibilities clearly allocated and communicated.	Satisfactory – meet minimum competence and resource requirements, but skills and capacity for innovation may be insufficient.
4	Established – has been in place for a number of years and as such is documented and associated training is in place. It may not be fully integrated with other processes.	Good – inventory is complete and quality and quantity is improving.	Good – All responsibilities clearly allocated and communicated. Some competency management and emergency response arrangements in place.	Competent – competence and/or resource above minimum requirements, and skills and capacity available to promote innovation and improve efficiency.
5	Fully embedded – mature and fully documented, associated training is in palace and it is integrated with other processes.	Comprehensive – inventory is complete, accurate, up-to-date and sufficient to support all SIM activities.	Excellent – All responsibilities clearly allocated and communicated. Full competency management and emergency response systems in place and periodically reviewed.	Excellent – competence and resources above minimum requirements with suitable skills and capacity to actively innovate and improve efficiency.

14. REFERENCES

[1] Health and Safety Executive, Key Programme 3 Asset Integrity Programme, 2007, http://www.hse.gov.uk/offshore/kp3.pdf.

[2] Health and Safety Executive, Structural Integrity Management Technology review report, to be published.

[3] Health and Safety Executive, Structural Integrity Monitoring - Review and Appraisal of Current Technologies for Offshore Applications, to be published 2008

[4] International Standards Organisation, ISO 19902:2007, Petroleum and natural gas industries - Fixed steel offshore structures.

[5] American Petroleum Institute, Recommended Practice for the Structural Integrity Management of Fixed Offshore Structures, API recommended practice, March 1 2007 Draft for Task Group Review and Comment.

[6] The Institute of Asset Management, PAS 55-1:2003, Asset Management, Part 1. Specification for the optimized management of physical infrastructure assets, April 2004.

[7] Health and Safety Executive, Offshore Installations (Safety Case) Regulations 1992, HSE Books, London, 1992.

[8] Health and Safety Executive, Offshore Installations and Wells (Design and Construction, etc.) Regulations, HSE Books, London, 1996.

[9] Health and Safety Executive, Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations, HSE Books, London, 1995.

[10] J.V. Sharp, A. Stacey and M. Birkinshaw, The Application of Performance Standards to Offshore Structural Components, Paper OMAE99-2071, Proceedings of the 18th International Conference on Offshore Mechanics and Arctic Engineering, St. John's (Nova Scotia), 1999, American Society of Mechanical Engineers, New York.

[11] Institute of Energy, Guidelines for the Management of Safety Critical Elements, 2007.

[12] Health and Safety Executive, Offshore Installations (Safety Case) Regulations 2005, HSE Books, London, 2005.

[13] Health and Safety Executive, Information Sheet 4/2006, Offshore Installations (Safety Case) Regulations 2005, Regulation 13, Thorough Review of a Safety Case.

[14] Health and Safety Executive, Hazardous Installation Directorate, Offshore Division, Structural Integrity Strategy, Rev 1, 2005.

[15] Marine Technology Directorate Limited, Appraisal of Marine Growth on Offshore Installations, Report MTD 92/102, 1992.

[16] Health and Safety Executive, Structural Integrity of Offshore Installations for Life Extension, HSE internal document – to be published.

APPENDIX A

Useful references for structural evaluation and assessment

The following references provide useful information on structural evaluation and assessment:

ABS 2003, American Bureau of Shipping, Guide for the Fatigue Assessment of Offshore Structures,

API 1993, American Petroleum Institute, Recommended Practice for Planning, Designing & Constructing Fixed Offshore Platforms, API RP 2A. 20th edition,

API 1997a, American Petroleum Institute, Recommended Practice for Planning, Designing & Constructing Fixed Offshore Platforms API RP 2A, section 17 – assessment of existing installations,

D.En 1974, Department of Energy, SI 289 (1974) Offshore Installations (Construction & Survey) Regulations, HMSO

D.En 1990, Department of Energy, Offshore Installations: Guidance on Design, Construction, and Certification, Fourth Edition, 1990

D.En 1991, Department of Energy, Reassessment of Older Platforms" - Final report to Dept. Of Energy, 1991, Offshore Certification Bureau OTN -91 -125

DnV 1991a, Det Norske Veritas, - Classification Note 30.6, Structural reliability methods

DnV 1993, Det Norske Veritas, Recommended Practice – Cathodic Protection Design, RP B401

DnV 2000, Det Norske Veritas, Fatigue Strength Analysis of Offshore Steel Structures, RP-C203

DnV, 2003, Det Norske Veritas, Offshore Service Specifications DNV-OSS-101, Special provisions for ageing units.

HSE 1992, Health & Safety Executive, Offshore Installations (Safety Case) regulations, HSE Books

HSE 1996b, Health & Safety Executive, Offshore Installations & Wells (Design & Construction) Regulations, HSE Books

HSE, 1999a, Health & Safety Executive, Detection of Damage to Underwater Tubulars and its effect on strength, OTO 99 084

HSE, 1999b, Health & Safety Executive, Report OTO 99 015

HSE 2003b, Health & Safety Executive, Review of the performance of high strength steels used offshore, Research report 105, HSE Books

ISO 1996, Standards, ISO 2394, General Principles on reliability for structures, DIS, 1996

ISO 2001, Bases for design of structures – assessment of existing structures, ISO 13822

ISO 2002a, Petroleum & Natural Gas Industries – General Requirements for Offshore Structures, BS EN ISO199900:2002

ISO 2002b, Petroleum & Natural Gas Industries – Offshore Structures, Fixed Offshore structures, 19902,

NORSOK 1998, Design of Steel Structures, N-004

NORSOK 1997a, Structural Design, N-001

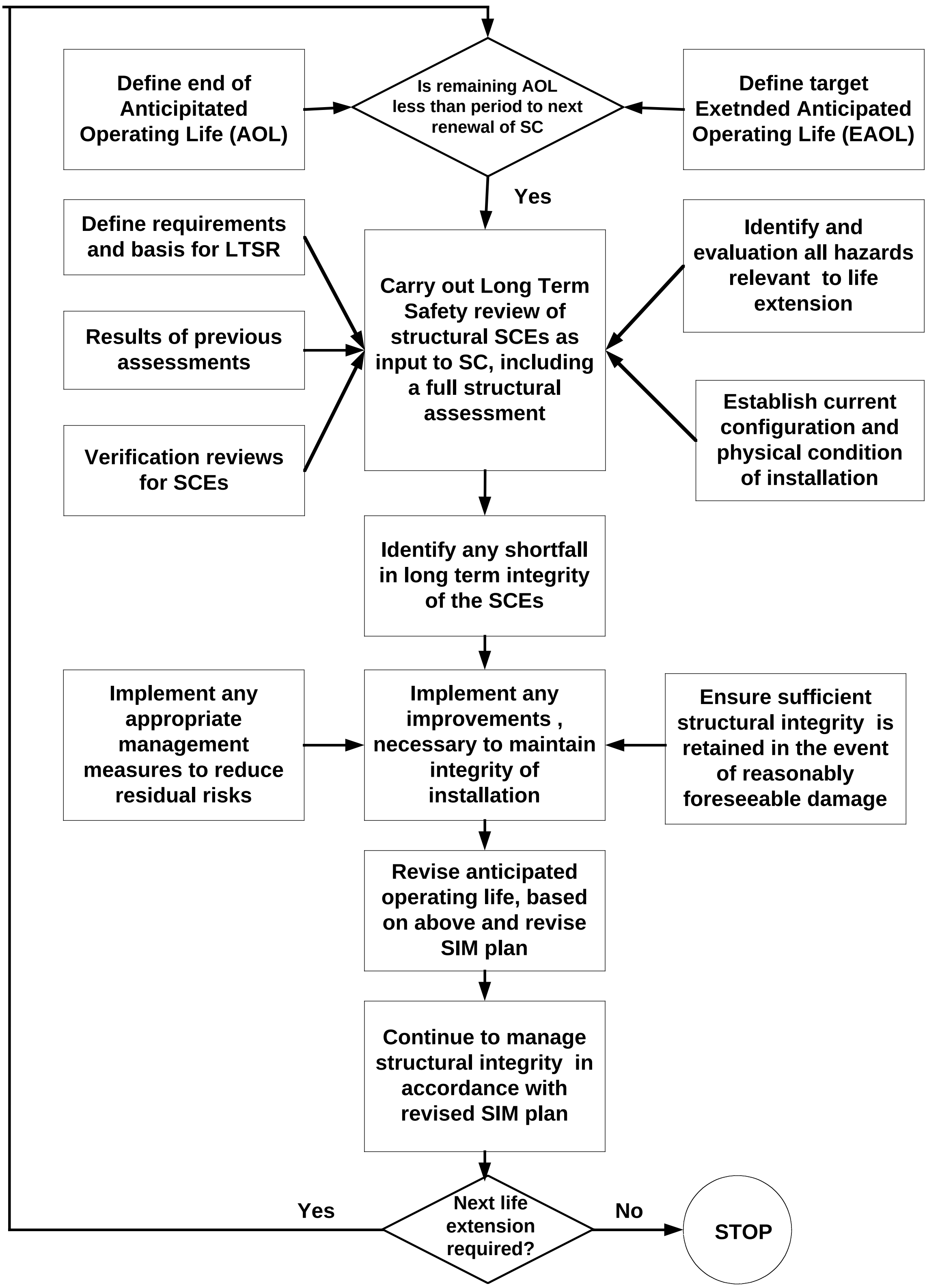
NORSOK 1997b, Cathodic Protection, M-503

NORSOK 1997c., Condition Monitoring of Load bearing Structures, N-005

Stacey A, Birkinshaw M, Sharp J.V., 2002, Reassessment Issues in Life Cycle Structural Integrity Management of Fixed Offshore Installations, OMAE Conference Oslo, Paper no. 28610.

APPENDIX B

Process for meeting the structural integrity requirements for life extension [16]


Define end of Anticipitated Operating Life (AOL)
Is remaining AOL less than period to next renewal of SC
Define target Exetnded Anticipated Operating Life (EAOL)
Yes
Define requirements and basis for LTSR
Results of previous assessments
Verification reviews for SCEs
Carry out Long Term Safety review of structural SCEs as input to SC, including a full structural assessment
Identify and evaluation all hazards relevant to life extension
Establish current configuration and physical condition of installation
Identify any shortfall in long term integrity of the SCEs
Implement any appropriate management measures to reduce residual risks
Implement any improvements , necessary to maintain integrity of installation
Ensure sufficient structural integrity is retained in the event of reasonably foreseeable damage
Revise anticipated operating life, based on above and revise SIM plan
Continue to manage structural integrity in accordance with revised SIM plan
Yes
Next life extension required?
No
STOP

HSE

Health and Safety
Executive

Structural integrity management framework for fixed jacket structures

With many offshore installations in the UK sector of the North Sea now reaching or exceeding their original anticipated design life, there is a particular need to evaluate approaches to structural integrity management by offshore operators to ascertain their adequacy in managing aging structures. In addition to this, a significant proportion of the aging structures are now operated by duty holders who are relatively new to the UKCS, and may not be following recognised good practice for structural integrity management.

A pilot study by HSE, undertaken during 1995-1996 and the results of the KP3 audit programme have highlighted the varying approaches to structural integrity management by duty holders, in terms of both the methods used and their effectiveness.

The objective of the study presented in this document is to develop a comprehensive framework for the structural integrity management (SIM) of fixed jacket structures reflecting the Health and Safety Executive Offshore Division's technical policy. This framework is a medium for communicating what HSE regards as good industry practice and thereby to stimulate duty holders' continual performance improvement.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the author alone and do not necessarily reflect HSE policy.

RR684

www.hse.gov.uk