Health & Safety Executive

Offshore Safety Division

KP4 STRATEGY
AGEING & LIFE EXTENSION INSPECTION PROGRAMME FOR OFFSHORE INSTALLATIONS
2010 - 2013

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1. **INTRODUCTION**

This document describes HSE’s Offshore Division’s (OSD’s) strategy for Key Programme 4 (KP4), the Ageing and Life Extension (ALE) Inspection Programme.

The ALE Inspection Programme is a key element of OSD’s work on ageing infrastructure whose aim is to promote awareness and management of the risks associated with ageing plant in the offshore oil and gas industry in support of four identified priority areas, i.e.

- Asset integrity
- Competence
- Safety culture
- Leadership.

This strategy identifies the basis for OSD’s inspection programme on ALE.

2. **BACKGROUND**

Ageing is characterised by deterioration which, in the severe operational environment offshore, can be significant with serious consequences for installation integrity if not managed properly. In the extreme case, failure could cause the total loss of an installation, with little chance of survival.

The establishment of a suitable asset integrity management (AIM) system provides the principal barrier safeguarding those working offshore. The integrity management of ageing installations and the successful implementation of an AIM plan for life extension depends on understanding the degradation processes, accurate knowledge of both the condition of a structure and the response of the structure in the aged condition and an implementation strategy to deal with the increasing risk of failure with time which enables the greater likelihood of deterioration to be predicted, detected and assessed.

The basis of an AIM system is provided by risk-based goal-setting offshore regulations, supporting guidance, industry standards, risk assessments and performance standards from which owner/operator policies can be developed. Further guidance from Oil & Gas UK is also available.

Regulation 13 of the Offshore Installations (Safety Case) Regulations 2005 (OSCR) requires duty holders to thoroughly review current safety cases with in five years of the previous acceptance or review, to confirm that the safety case as a whole continues to be fundamentally sound, and continues to demonstrate the effective identification, management and control of major accident hazard risks on the installation, as described in Paragraph 187-190 of the L30 Guide to OSCR 2005. The Regulation is not time-constrained and so places an enduring burden of responsibility on employers to ensure, so far as is reasonably practicable, the health, safety and welfare at work of employees and those not in his employment.

3. **AIM AND OBJECTIVES**

The aim of the ALE strategy is to ensure that risks to asset integrity associated with ALE are being controlled effectively.

The objectives of the strategy are:
• to raise awareness of ALE in the offshore industry of the need for specific consideration of ageing issues as a distinct activity within the AIM process;
• a programme of inspections of duty holder approaches to the management of ALE;
• to identify areas for improvement of ALE management and encourage improvements;
• to encourage development of good practices.

4. METHODOLOGY

There is a programme of onshore and offshore inspections of the ALE and AIM systems to establish whether the risks are being managed effectively and to encourage improvements:

(1) encourage sharing of ALE knowledge;
(2) review trends associated with ALE;
(3) review existing ALE-related publications, and where possible, create new publications to help new guidance supporting a programme of research on ageing / life extension aspects of asset integrity to inform both HSE and the offshore industry on the safe operation of ageing installations and for the development of standards and guidance;
(4) where possible, review and update HSE guidance on the thorough review process.

INDICATORS OF AGEING

Ageing is more likely to be an issue in the following situations:
• high cycling rate of extreme temperatures, pressures, loads or flexing;
• history of operating at the limit of, or beyond original design envelope;
• high pressures and temperatures;
• corrosive environments (internal and external);
• legacy of inadequate maintenance and inspection;
• obsolete equipment and software which may not be supported by the manufacturer.

The clearest evidence will be where:
• there are frequent or recurring defects and failures;
• increasing trends of unplanned maintenance, repairs and breakdowns;
• signs of degradation;
• plant has been down-rated;
• increasing inspection and testing frequency to manage degradation.

The following could indicate situations where the potential for ageing is not being identified or monitored:
• inadequate record keeping;
• not using inspection / test findings to modify monitoring frequencies;
• incomplete SCE register.
5. PRIORITY AREAS

5.1 Overview
The strategy covers the key ageing and life extension considerations for all relevant hazard areas, namely:

- Corrosion and materials
- Mechanical integrity
- Electrical, control and instrumentation
- Pipelines
- Fire, explosion and risk assessment
- Process safety
- Human and organisational factors
- Structural integrity
- Maritime integrity
- Wells

5.2 Corrosion and Materials
Offshore equipment is subject to a range of degradation threats which can alter the risk profile. The two most important consequences of inadequately controlled corrosion are loss of hydrocarbon containment and structural failure; which will be the main focus for the ALE programme for Corrosion and Materials topic area.

OSD will review duty holders’ corrosion management systems (CMS) to assess suitability for ALE knowledge and management, including evidence of duty holders anticipating future corrosion threats, knowledge of SCEs and accurate databases, via:

- corrosion risk assessment (CRA);
- risk-based inspection programme (RBI);
- corrosion management strategy (CMS).

5.3 Electrical & Control systems Integrity (EC&I)
A typical offshore installation contains many safety critical systems that utilise electrical, electronic, programmable or other technology devices, including power generation and distribution, and control of process and safety systems. Design life of these systems can be expressed in terms of number of operations, hours of operation, whilst many systems have no explicit design life or means by which the design life can be determined.

OSD will look for evidence that duty holders maintain equipment in good working order, their identification and effective management of ALE issues including obsolescence, by offshore and onshore inspection of procedure and equipment. The scope of the electrical control and instrumentation (ECI) aspects of KP4 are safety critical elements (SCEs) whose functions are solely or primarily dependent on electrical and/or control principles, including anticipation of the potential energy and safety demands of the future.

5.4 Fire, Explosion and Risk Assessment
Whilst an installation’s process hazard profile generally decreases due to reductions in flammable fluid flow rates and pressure, plant and work equipment tend to degrade over time, resulting in a reduction in integrity and reliability. The assessment of risks to persons on ageing installations needs to take account of these two competing situations. It is necessary to monitor changes in plant condition, determine their significance by performing formal risk reassessments, taking into account advances in technology to ensure the effective management of the risks presented by fire and explosion (F&E) hazards. Effective F&E management means leaks can be detected early to initiate control, protection and shutdown.
measures, and in the event of such scenarios, deluge will keep structures cooled and there is a safe temporary refuge (TR) for workers to retreat to, until the situation is controlled. Further guidance is available.

Besides reviewing duty holders’ awareness of obsolescence issues, OSD will also review the following, in terms of their location and efficacy:

- leak, and fire detection systems, active and passive fire protection (AFP and PFP) systems, against identified fire scenarios and failure criteria of the item being protected.
- heating, ventilation and air conditioning (HVAC) systems, for the (extended) life of the asset to ensure that TRs remain as safe havens with indicators to show effective sealing in the event of a leak/fire.

5.5 Human and Organisational Factors (HOF)

To manage ALE, duty holders should have effective ALE policies, strategic objectives and a suitable organisational culture in place to develop and deliver long-term plans. OSD will review the organisational safety culture, including awareness and understanding of ALE, workforce involvement, key responsibilities, management structure, communications and resources and management measures that differentiate life extension from day-to-day AIM. The offshore industry’s safety culture should recognise the barriers to the catastrophic loss of integrity that risk-based management systems, standards and technical specialists provide. Leadership is needed to ensure suitable and sufficient resources are deployed and that ageing matters becomes embedded in the safety culture.

There should be a suitable succession planning and a training programme in place for critical staff as well as contractors, to ensure competency as well as to retain corporate knowledge due to the ageing specialist workforce and high staff turnover.

5.6 Maritime Integrity

For FPSOs and MoDUs, an effective marine integrity management system is fundamental to the safety of the entire asset. Inspections will look for evidence that duty holders have a good understanding of the integrity of the existing structures, effective inspection programmes, and are able to trend degradation rates to enable anticipation of unsafe conditions. In particular, OSD will review ageing issues for maritime integrity, with the potential to cause loss of stability & position, including deterioration mechanisms, modifications, weight control, original design basis against current standards and obsolescence in marine systems.

OIS 5/2007 sets out the key issues that affect the management of maritime integrity and clarifies the need for the reassessment of integrity and review of the management arrangements, including the inspection strategy and plans for replacement or repair of structural components and marine systems. An important aspect of the process is review of the input parameters (e.g. environmental criteria and loading) and the effect of advances in knowledge, technology and standards. The guidance also considers marine systems such as: weather and watertight closing appliances; systems for ballasting and stability; systems for mooring and positioning; and related safety systems which depend on emergency power or hydraulics.

5.7 Mechanical Integrity

Effective pressure containment of vessels and pipework is essential to minimise the risks of leaks or bursts. The principal ageing mechanisms for topside mechanical systems are corrosion, erosion, fatigue and obsolescence. ALE issues of mechanical systems are closely linked to the adequacy and effectiveness of the inspection, testing, maintenance and
calibration regimes of the installation. These need to reflect the potential for accumulating and accelerating deterioration, particularly when operating close to and beyond the original design life, and advances in knowledge and technology.

OSD will review duty holders’ understanding of the condition of their assets and assess whether effective management systems are in place. Duty holder mechanical integrity management should cover the following systems: Hydrocarbon-containing equipment; machines and rotating equipment; cranes; non-metallic (composite) piping / vessels; and seals.

5.8 Pipelines

Failure to manage ageing and degradation mechanisms in offshore subsea pipelines could result in risks to platform personnel, environmental damage and costly replacements. OSD will review duty holders’ strategy for ALE management of pipelines exceeding design life. The review will include pipeline safety management systems, including consideration of consequences of the accumulation of defects which could reduce pipeline integrity. This includes the development and maintenance of a Pipeline Integrity Management (PIM) System to capture inspection and maintenance activities, condition monitoring, incidents and repairs, etc. and established a system of monitoring and recording pipeline operational data, i.e. flowing parameters and hydrodynamic loading. Guidance 16,17 on what is required to make an adequate demonstration for pipeline ALE management is available.

5.9 Process Integrity

Process safety considers the understanding and mitigation of risks associated with operating equipment containing hydrocarbons at high pressures and temperatures. OSD will review whether duty holders have a clear understanding of process safety risk management, under changing conditions. Three key performance indicators (KPIs) provide a clear view of the consequences of ageing in process integrity.

Firstly, loss of containment incident rate is a key measure of the onset of wear out. Because it is an exponentially increasing failure period, containment failure events should be identified and analysed to determine if a particular type or region of process equipment is beginning to lose integrity. The necessary measures can then be determined to re-establish integrity to the intrinsic failure period expectations. Following the ‘weep before leak before break’ philosophy, it is essential that all loss of containment events are recorded to enable adequate analysis and remediation.

Secondly, operational risk assessments (ORAs) are needed when there are deviations from an installation’s design intent, to provide an indication of potential flaws, or if plant is not adequately maintained or is used outside of its intended operating envelope or design parameters.

Thirdly, successful safety management in plant / process modification begins at the concept stage and must be maintained for the remaining for the life of the plant. As an installation ages, well fluid properties may change to such a point where the original process design is no longer valid, e.g. a reducing pressure profile where several stages of high pressure to low pressure process operations are no longer necessary or water cut increases, rendering it difficult to reduce the hydrocarbon content of produced water. Under such circumstances, large sections of the process facilities and utilities) may become redundant and a revision of the process train and the removal of equipment may be appropriate. Alternatively, life extension may occur as a result of the development of new resources that tie-in new well fluids to existing process equipment. In both cases, there is the potential to expose the process train to conditions of hydrocarbon, composition, pressure or temperature where such plant is approaching or operating in its ‘wear out’ phase, or cause exposure to parameters outside its original design specification.
It is therefore necessary to ensure that the design specification is revalidated for all existing equipment where such changes are proposed or have been carried out, so that adequate control of change and project development procedures can be established and implemented.

5.10 Structural Integrity

Effective understanding of structural degradation and failure mechanisms are imperative to prevent structural failures leading to hydrocarbon releases or other catastrophic consequences. OSD will review duty holders’ Structural Integrity Management (SIM) system and its consideration of ALE, including management of deterioration mechanisms, including that in uninspectable components. A key aspect of any SIM strategy is understanding of the position of assets in the life cycle and whether they are fit for purpose for life extension, including the consideration of the increased uncertainty associated with the asset’s structural integrity and its assessment. These may be due to:

- changes in ownership and cycles of contracting out structural integrity management activities, contributing to loss of corporate knowledge, e.g. on the design criteria, the history of inspection and repair and accidental damage.
- the presence of fabrication defects, which may become more significant in aging installations under the sustained impact of the harsh environmental loading.
- insufficient knowledge of the structures’ condition due to the limitations of current inspection techniques (e.g. GVI and FMD).
- the development of new guidance.

The successful implementation of a SIM plan for ageing and life extension depends on the availability of an appropriate level of data on the actual condition of the structure, the use of suitable inspection techniques at appropriate intervals, reliable assessment methods and an implementation strategy to deal with the increasing risk of failure with time.

Where structures have come to the end of the design life or suffered significant damage, reassessment of the structural integrity should be performed to demonstrate that existing installations continue to meet regulatory requirements. The principal sources of guidance on reassessment are API RP 2A\textsuperscript{10,11}, ISO 19901\textsuperscript{12}, ISO 19902\textsuperscript{13} and NORSOK\textsuperscript{14}.

5.11 Wells

OSD will review the following SCEs: tubing; casing; cement; annulus safety valves; wellheads and X-mas trees, to ensure degradation mechanisms have been considered. There should be a well integrity management (WIM) programme involving monitoring of process and operational parameters, inspection of the well completion system, with recognition of uninspectable areas (e.g. subsea wellheads), repair / replacement of casing, production string, pressure testing to verify effective repair of well completion systems, the review and use of new technology where appropriate, and an awareness of material properties and degradation mechanisms.

The WIM programme should consider methods for downhole inspection and monitoring of material behaviour; fatigue performance of subsea wellheads and and leakage frequencies of X-mas trees due to weight and movement from BOP, riser and rig from well intervention and from side track drilling; wear, especially in the production tubing and wellhead and risers (subsea wells) from the drill string; loads during drilling, production and workover – the inaccessibility of critical sections be low the wellhead; the availability of new equipment and methods or alternative operational procedures to reduce loads and fatigue of subsea wellhead and X-mas trees; and geological effects from subsidence, such as slippage between layers (faults).
6. STAKEHOLDER ENGAGEMENT

OSD will encourage consideration and management of ALE issues and the development of ALE guidance. An HSE ALE webpage is available at http://www.hse.gov.uk/offshore/ageing.htm

Offshore Information Sheet OIS 4/2009 will be expanded to key ALE topic specialisms to help with industry guidance. GASCET has been reviewed and updated.

7. PROGRAMME MANAGEMENT

KP4 has a Programme Review Team (PRT), reporting via the team leader to the Head of Division and the Divisional Management Team (DMT). The PRT will:

- monitor the development of ALE guidance;
- oversee the progress of the ALE Programme;
- review inspection findings;
- consider research requirements;
- disseminate information;
- engage with industry.

Technical support will be provided by HSL.

The KP4 programme commenced in July 2010 and will run to December 2013. On completion of the inspection programme, the findings will be evaluated, reported and disseminated. The PRT will meet regularly to discuss findings and evaluate progress. An interim report will be delivered in 2012. The Programme Manager and DMT Programme Champion will meet regularly to discuss progress. Monthly progress reports will be provided to the DMT.

The ALE Inspection Programme is a key priority for OSD, supporting OSD’s work on Asset Integrity identified in the HID OSD Business Plan. The inspections will contribute to inspectors’ annual work plan. The inspection teams will be asked to enable the onshore and offshore inspections with the duty holders.
REFERENCES


[18] GASCET (Guidance for the topic assessment of the major accident hazard aspects of safety cases) http://webcommunities.hse.gov.uk/connect.ti/gascet/view?objectld=62036&exp=e1

APPENDICES

OTHER RELEVANT DOCUMENTS


STANDARDS

The level of integrity is set by regulations and class rules on the UKCS, by PSA regulations and guidance and the NORSOK standards in Norway, and by API standards in the USA. For structural integrity management, the ISO offshore standards provide a common approach and make specific reference to life extension – see below. General principles are given in ISO 13822 (Assessment of Existing Structures) and ISO 19900 (Offshore Structures – General Requirements)

Standards on topsides facilities

- API 521;
- API 14C;
- ISO 10418.
- ISO 13822: Basis of design of structures – Assessment of existing structures
- ISO 19900: Offshore Structures - General requirements
- ISO 19903: Concrete Installations (ISO 19901-19902 already listed in References)
- ISO 19904: Floating Installations
- ISO 19905 –1: MODU & Jack-Up Installations

Standards on ageing mechanisms and their management

- API RP 571, Damage Mechanisms Affecting Fixed Equipment in the Refining Industry
- API RP 573, Inspection of Fired Boilers and Heaters
- API RP 574, Inspection Practices for Piping System Components
- API Standard 1160, Managing System Integrity for Hazardous Liquid Pipelines. Corrosion, Shrier, Elsevier
- Fitness-for-Service and Integrity of Piping, Vessels and Tanks. ASME Code Simplified. Antaki
- API RP 1632 (2002), Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems
- BS EN 1504, Products and systems for the protection and repair of concrete structures
- BS EN 12696:2000, Cathodic Protection of Steel in Concrete
- IEC 61511 Functional safety – Safety instrumented systems in the UK process industries

Good practice guidelines

- RR 253, Piping Systems Integrity, Management Review
- PAS 55, Asset Management, The Institute of Asset Management
- Best Practice for Risk Based Inspection as a Part of Plant Integrity Management, CRR 363/2001
• UKOOA Guidelines VES06 - FPSO Design Guidelines
• SNAME 5-5A, Site Specific Assessment of Jack-Up Structures
• DNV/SINTEF/BOMEL ULTIGUIDE – Best Practice Non-Linear Analysis Guidelines
• OTO 2001 010: Environmental Considerations
• HSE’s Guidance on ALARP for Offshore Inspectors - Making an ALARP Demonstration (http://www.hse.gov.uk/hid/spc/enf38.htm)
• HSE Research Report 076, Machinery and Rotating Equipment Integrity Inspection Guidance Notes
• Human Factors HSE Inspectors Toolkit, HSE web-site
• NACE Corrosion Engineer’s Reference Book, 3rd Edition
• Concrete Repair According to the New European Standard EN 1504, Prof Dr Ing M Raupach, RWTH Aachen, ibac
• HSG 254, Developing Process Safety Indicators, HSE Books
• HSE Human Factors Briefing Note No. 2 – Competence, HSE website
• HSE Technical Measures Document – Maintenance Procedures, HSE website
• HSE Human Factors Briefing Note No. 11 – Organisational Change, HSE website
• AEA Technology, Developments in electrification systems – Life expectancy of electrical equipment, AEATR-EE-2005-030, June 2005
• HSE CRR 428(2002), Principles for proof testing of safety instrumented systems in the chemical industry
• EEMUA 222:2009 Guide to the Application of IEC 61511 to safety instrumented systems in the UK process industries ESR/D0010909/005/Issue 1
• EEMUA 191:2007 Alarm systems -a guide to design, management and procurement