Key Programme 4 (KP4)  
Ageing and life extension

An interim report by the Offshore Division of HSE’s Hazardous Installations Directorate

November 2012
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### Glossary

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<td>Asset integrity management</td>
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<td>ALE</td>
<td>Ageing and life extension</td>
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<td>CMS</td>
<td>Corrosion management system</td>
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<td>CTA</td>
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<td>Corrosion risk assessment</td>
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<td>EC&amp;I</td>
<td>Electrical, control and instrumentation</td>
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<td>ESDV</td>
<td>Emergency shut down valve</td>
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<td>FPSO</td>
<td>Floating production storage and offloading vessel</td>
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<td>HAZOP</td>
<td>Hazard and operability study</td>
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<td>HCR</td>
<td>Hydrocarbon release</td>
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<td>Health and Safety Laboratory</td>
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<td>HVA</td>
<td>Heating ventilation and air conditioning</td>
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<td>ICP</td>
<td>Independent competent person</td>
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<td>IMT</td>
<td>Inspection management team</td>
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<td>IIWG</td>
<td>Installation integrity work group</td>
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<td>IVB</td>
<td>Independent verifying body</td>
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<td>KP4</td>
<td>Key Programme 4</td>
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<td>KPI</td>
<td>Key performance indicator</td>
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<td>MAH</td>
<td>Major accident hazard</td>
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<td>Major Accident Hazards Bureau</td>
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<td>Major Accident Reporting System</td>
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<td>MMS</td>
<td>Maintenance management system</td>
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<td>MoDU</td>
<td>Mobile drill unit</td>
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<td>NACE</td>
<td>National Association of Corrosion Engineers</td>
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<td>NDT</td>
<td>Non-destructive testing</td>
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<td>NUI</td>
<td>Normally unattended installation</td>
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<td>Offshore inspection engineer</td>
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<td>ORA</td>
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<td>Semi-permanent circular</td>
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<td>SCE</td>
<td>Safety-critical element</td>
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<td>SCiS</td>
<td>Step Change in Safety</td>
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<td>TA</td>
<td>Technical authority</td>
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<td>TR</td>
<td>Temporary refuge</td>
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<td>UKCS</td>
<td>UK Continental Shelf</td>
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Summary

In July 2010, the Health and Safety Executive’s (HSE’s) Offshore Division (OSD) launched Key Programme 4 (KP4). This inspection programme aims to improve the management of the consequences of the ageing of UK offshore installations, especially given the growing demands to extend their use beyond the original design life. KP4 will run until December 2013 and this interim report describes the progress of the programme to date.

KP4 involves raising the profile of offshore ageing and life extension (ALE) issues through a series of targeted inspections which aim to improve management of ALE and to identify current good practices. KP4 follows on from HSE’s previous Key Programme 3 (KP3)* on asset integrity management in 2009, and the Offshore External Corrosion Project† in 2010.

At this stage of the programme, 18 hydrocarbon production dutyholders and three drilling operators, approximately 65% of the offshore industry, have had onshore and offshore KP4 inspections.

The industry has reacted well to this initiative, with the majority of dutyholders positively engaging with the ALE concepts. Indeed, as a result of KP4, many dutyholders have undertaken independent reviews of their integrity management practices in preparation for extending the life of already ageing offshore assets, and are developing long-term, installation-specific integrity management plans.

HSE has seen good evidence that industry senior management recognise the importance of ALE issues, and is particularly pleased that KP4 has stimulated the industry to initiate the development of guidance documents using their pooled resources under Oil and Gas UK (OGUK).

However, the industry has still much to do to ensure that installation long-term plans anticipate and manage the effects of equipment and infrastructure degradation. A range of issues requiring improvement across the industry are identified in this interim report.

Industry associations such as OGUK have already formed specific work groups to create ALE guidance, but these need to be expanded to ensure that all ALE learnings are captured and shared throughout the industry. The remainder of KP4 will build on the successes to date to stimulate further improvements across the industry.

Workforce involvement is of key importance to health and safety matters, and it is encouraging that, as a result of KP4, dutyholders have held specific ALE events to engage with the offshore workforce. However, more is required, possibly using innovative approaches to involve the workforce in the long-term management of ageing offshore assets as the UK’s offshore industry grows in maturity, a subject on which OSD is in discussion with Step Change in Safety (SCiS).**

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** http://www.stepchangeinsafety.net/
Introduction

Approximately 50% of the fixed platforms on the United Kingdom’s Continental Shelf (UKCS) have exceeded their original design life, often specified as 25 years, and a significant number of floating installations are similarly approaching or have exceeded it.

This obviously has implications for asset integrity as, for instance, onshore studies have found* that approximately 60% of major accident incidents are related to technical integrity and, of these, 50% have ageing as a contributory factor. Similarly, the Major Accident Reporting System database (MARS) held by the EU Major Accident Hazards Bureau (MAHB) estimates that 28% of all reported major accident loss of containment events are due to ageing.

As there is business and national interest in producing oil and gas for longer than initially anticipated, the majority of UKCS installations are likely to remain operational for a significant period of time.

The management of ageing is therefore crucial, and begins with an awareness that ageing is not about how old the infrastructure is, but rather what is known about its condition and the factors that influence the onset, evolution and mitigation of its degradation: ‘Ageing is not about how old your equipment is; it’s about what you know about its condition, and how that’s changing over time.’† This emphasises the importance of KP4.

In simple terms, the KP4 programme aims to ensure that the risks to asset integrity associated with ageing and the life extension of infrastructure are being effectively controlled, and it is in support of OSD’s strategic priority on asset integrity. The objectives of KP4 are to:

- raise awareness of ALE issues as part of asset integrity management (AIM) systems;
- inspect dutyholders’ approaches to the management of ALE;
- identify and share good ALE management practices and encourage the industry to develop guidance;
- identify areas for improvement in ALE management and encourage workforce involvement.

Ageing is characterised by deterioration, which in the severe operational environment of the offshore industry can have serious consequences if not properly managed – the worst case being the potential loss of an installation and those aboard. Ageing is not just limited to hardware, but encompasses broader aspects of processes and procedures, software, and control systems. Most importantly, it is also about the people working in the offshore industry, their skills, competence and succession planning, and the management and corporate cultures within which they work.

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† Plant Ageing – Management of equipment containing hazardous fluids or pressure HSE Research Report RR509 (http://www.hse.gov.uk/research/rhtm/index.htm)
The complexity of the subject has meant that raising the awareness and importance of ALE has been a central priority for the KP4 programme. In simple terms, this has been achieved through working with the industry and other offshore regulators, the creation of an HSE KP4 website,* and events involving senior management, technical specialists and the workforce.

The KP4 programme has engaged with offshore stakeholders across the industry, but in particular OGUK, SCiS, and other North Sea regulators.† The KP4 website has aimed to support this engagement by acting as a conduit for sources of information on ALE in the industry worldwide. The KP4 programme has catalysed the engagement of the industry and its leaders, who see not just the potential improvements for offshore safety but also the possible commercial gains/business improvements of plant availability and reliability. An ALE session at Offshore Europe in 2011 particularly highlighted the importance of this.

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* http://www.hse.gov.uk/offshore/ageing.htm
† On a broader front, the offshore regulatory authorities of Norway (PSA), the Netherlands (SSM) and the USA (BSEE) have undertaken studies on ALE offshore, and the Organisation for Economic Development (OECD) is setting up an ALE study for European hazardous chemicals industries.
KP4 inspection programme findings

The KP4 inspection programme has covered a range of installations including steel jackets, concrete jackets, floating production storage and offloading vessels (FPSOs) and semi-submersibles. The inspections have identified a range of interim findings, which are described in the sections below.

Organisational factors

Effective organisational arrangements are essential for the management and delivery of ALE. KP4 organisational factors inspections were seeking evidence that dutyholders have effective ALE policies, strategic objectives, adequate resources and a suitable system in place to develop and deliver long-term plans for the management of ALE.

It was found that AIL was discussed frequently at senior levels in all dutyholders, that they have reacted positively to HSE’s initiative and were developing ALE policies and procedures through specific ALE task groups.

Examples were seen of sophisticated leading and lagging KPI ‘dashboards’, presenting easily digestible AIM information for senior management, an example of which is given in Figure 1.

**Figure 1** Asset ‘X’: An example dashboard

- **Lagging**
  - No barrier breaches during June 2012

- **Leading**
  - Corporate Tolerance Levels exceeded are:
    - Approved temporary repairs reduced from 18 to 14 repairs
    - 8 are on Hydrocarbon/Process Systems [CTL=6]
    - Deviations and ORAs increased from 7 to 8 [CTL=6]

- **Enduring issue (>2 months)**
  - MAHE system inhibits
  - Static at 2 inhibits

- **Key events from graph**
  - Maintenance backlog increased from zero to 6 tasks (48 hrs)
  - Temporary repairs reduced from 18 to 14 repairs. Permanent repairs carried out.

Current AIM workloads are high as dutyholders undertake significant upgrades, equipment maintenance programmes and fabric maintenance work. Despite this, all dutyholders were actively reviewing ALE management issues and either had developed ALE policies or were in the process of developing and embedding them into the AIM systems. There would be additional benefit if ALE policies and procedures were embedded into existing AIM programmes, with an ALE manager to oversee the broad ALE and obsolescence picture.
Independent ALE installation audits were commonplace and most companies had allocated a manager to oversee ALE criteria to encourage visibility and action. The presence of an offshore inspection engineer (OIE) on an installation was found to have significant AIM benefits, not only in terms of implementing the inspection programme, but also by being available for opportunistic inspections to identify ALE issues.

One dutyholder was reviewing commercial contracts to determine whether ALE and obsolescence issues could be considered. All were developing management tools to plan for ageing and life extension, and meeting agendas considered the issues of: ‘yesterday, today, tomorrow’.

Dutyholders have active succession planning programmes to anticipate and manage the potential loss of expertise, for example one company has a policy of operating with 15% excess staff to ensure the availability of expertise in the long term. Mentoring programmes were also in place to ensure that people new to the industry could develop their skills to provide expertise for the future.

For the remainder of the programme, an additional focus for the inspections will be control room obsolescence, workloads and organisational change.

**Process safety**

Process safety management is about preventing uncontrolled loss of containment of flammable hydrocarbons, which may result in a fire and/or explosion. Process safety in the context of ageing and life extension is recognising changes made to production rates, operating parameters, plant modifications, operating procedures and key drawings, and training needs during the lifetime of the process plant.

KP4 process safety inspections were therefore seeking evidence that management arrangements were in place for topsides hydrocarbon-containing equipment to prevent loss of hydrocarbon containments, manage change and risk assess day-to-day operational changes.

The inspections confirmed that existing routine operating and maintenance systems are widely used to identify most process safety ALE issues. In addition, good communication protocols for the distribution of documents, defining roles for responsibility, authority, consultation, and information were found. Tools are being developed to outline safety-critical elements (SCEs) which act collectively as barriers to prevent loss of containment of the protected process system.

Areas identified where dutyholders need to maintain ALE focus include:

- clearer mapping of SCEs comprising different layers of protection, eg safety integrity level (SIL) assessment;
- improved inspection of insulation condition where it is needed for process safety purposes. Where insulation can be removed this must be led by the process safety department to ensure removal of lagging doesn’t create hydrate problems in pressure relief valves;
- clear communication between departments to enable the identification and management of hazards, eg defined life repairs and flexible hose registers;
- maintenance of red-line mark-ups of key documents in the control room and permit offices offshore;
- more attention to control systems hardware and software obsolescence;
- initiatives on plant simplification and the removal of redundant equipment;
- risks associated with the vibration of small-bore tubing and pipework;
- awareness of changes to codes and standards, including HSE guidance etc.
Fire and explosion

Effective fire and explosion (F&E) management means leaks can be detected early to initiate control, protection and shut down measures. In the event of a fire and/or explosion, deluge and passive fire protection (PFP) will then keep the structures and equipment cooled, and there is a safe temporary refuge (TR) for offshore workers until the situation is controlled. The KP4 F&E inspections were therefore seeking evidence that the detection and fire monitoring devices would be effective, efficient and correctly located for the long term, and that TR performance standards could be maintained in the future.

The inspections found that management tools to plan for ALE were in place. For example, F&E asset reviews (with tracking registers) involving quantitative risk assessment (QRA), hazard and operability study (HAZOP), piping and installation diagram (P&ID) etc were aligned with the safety case five-year review.

Evidence of the performance trending of SCE testing data was found, with its subsequent use as an input to operational risk management for identifying plant deviations and hence making ALE decisions, particularly in spreadsheets identifying relationships between SCE failure and MAH risks.

Equipment failure and notification procedures were in place, and root cause analysis for inspection deviations was used to understand ALE failure mechanisms to take decisions for the longer term. TR impairment studies were in place to review the adequacy of the performance standards for future compliance.

Areas identified where dutyholders need to maintain ALE focus on F&E issues include:

- TR integrity management – including the establishment of appropriate SCEs and performance standards, testing, trend analysis and maintenance programmes for the long term;
- improving the functionality and reliability of obsolete gas detection systems rather than just changing ‘like with like’, to ensure performance standards will be met in the future;
- applying full-life costing to active fire protection and mitigation system upgrade decisions – taking account of maintenance routines, KPIs and trend analyses, and fitness for purpose assessments;
- audit and review of QRAs in line with the five-year Safety Case Thorough Review Summary (SC TRS) process;
- regular review and audit of operational risk management (ORM) to ensure it is fit for purpose. The number of MAH-related ORM ‘deviations’ can be directly linked to ageing issues. These should be actively managed and, when possible, the numbers reduced with permanent fixes.

Mechanical

Effective pressure containment of vessels and pipework is essential to minimise the risk of hydrocarbon releases. The KP4 mechanical inspections were looking for evidence that dutyholders understood the condition of their assets and had effective management systems in place.

It was found that dutyholders were taking greater control of integrity and maintenance management, often by bringing it back in-house, and were including ageing mechanisms into some HAZOPS to enhance long-term improvements. There were widespread examples of programmes for replacing defined life repairs with permanent solutions.
There was greater use of original equipment manufacturers’ (OEMs’) maintenance recommendations to ensure that maintenance tasks and schedules fully address potential in-service deterioration. Maintenance experts were advising on ALE, undertaking gap analyses, developing new ALE guidance documents, and improving anomaly management tools.

Areas identified where dutyholders need to maintain focus include:

- improved understanding of the effect and consequences of ALE on mechanical aspects, and the integration of this new understanding into AIM programmes;
- effective communications between onshore and offshore to enhance long-term AIM and safety management;
- achieving repair targets, including the review and audit of defined life repairs;
- improving fabric maintenance;
- reviewing organisational structures to minimise potential conflicts of interest, eg if the Integrity Manager reports to the Operations Manager;
- additional inspections of rotating equipment operating beyond design life;
- reviewing the fatigue assessments of pressure vessels beyond their design life (thermal and fatigue), and if necessary undertaking a re-baselining to extend fatigue lives, particularly for transferred assets;
- long-term maintenance strategy reviews for cranes to determine their suitability and long-term life.

**Corrosion**

Sub-optimal corrosion control can lead to the loss of hydrocarbon containment and structural failure, with the possibility of attendant safety and environmental implications.

The KP4 corrosion inspections looked for evidence of dutyholders anticipating future corrosion threats and having suitable risk-based inspection assessments, knowledge of the SCEs, and accurate databases.

For mature production installations where complete corrosion threats assessments (CTAs), risk-based inspection (RBI), and corrosion management system (CMS) programmes existed for process fluid equipment, they were found to be suitable for the future management of corrosion issues. All dutyholders had procedures in place to review and modify the CTAs and RBIs in the event of possible changes to process fluid corrosivity, for example when new hydrocarbon streams were brought into the process plant.

For younger production installations, dutyholders were recognising the need to review CTAs and RBIs in anticipation of corrosivity changes, eg increases in sulphate reducing bacteria and hydrogen sulphide. It was found to be standard practice to review the CTAs as part of the change management process before new fluids enter existing process streams.

All production dutyholders inspected have initiated fabric maintenance programmes to manage areas of degradation, with a number starting to use walk-to-work vessels to provide the extra resources needed to liquidate the backlogs. The inspections found good AIM inter-departmental communication, and good cross-industry corrosion management knowledge sharing under the umbrella of the Energy Institute (EI).

Areas identified where dutyholders need to maintain ALE focus on corrosion include:

- regular onshore and offshore review and audit of the CTAs, RBIs and CMSs to verify the accuracy of the scope and implementation;
- checking line lists to reflect changing use and redundancy;
Health and Safety
Executive

- auditing inspection data to ensure correct collation for long-term integrity predictions;
- providing high-reliability chemical injection systems which require less operator intervention;
- on-time implementation of fabric maintenance programmes across the North Sea.

**Electrical, control and instrumentation**

Ageing electrical infrastructure can lead to an increased risk of ignition in the event of a major loss of hydrocarbon containment if not managed adequately. The KP4 EC&I inspections were looking for evidence that dutyholders had identified and effectively managed the ageing and obsolescence of EC&I equipment and systems, and had plans to prevent failure which could cause or contribute to a major accident.

The scope of the EC&I inspections included critical power generation and distribution, process, well-related safety-instrumented systems and emergency support systems such as emergency shut down (ESD) and public address/general alarm (PA/GA).

It was found that dutyholders have effective arrangements for the regular inspection of EC&I equipment and day-to-day maintenance. Dutyholder senior management commitment to KP4 and its aims was evident and positive, with all working to have plans in place to effectively manage all aspects of EC&I ageing and obsolescence. However, workloads are high, detracting from ALE considerations.

Obsolescence presents a particular difficulty for EC&I equipment, with advances in technology meaning that the lifetime of equipment is often limited by the availability of spare parts and vendor support. Good evidence was found of dutyholders undertaking obsolescence reviews and planning for the refurbishment or replacement of critical EC&I protection and support systems such as fire and gas detection, emergency shut down systems and high-integrity process protection systems.

Areas identified where dutyholders need to maintain ALE focus on EC&I include:

- measurement and analysis of failure trends to identify future repair or replacement needs;
- improved understanding of equipment obsolescence issues to guide when to replace, or when to purchase extra spares in anticipation that vendors will cease support.

**Structures**

A good understanding of the behaviour of the structure, and the degradation and failure mechanisms of critical structural elements, is imperative to prevent structural failures leading to hydrocarbon releases or other catastrophic consequences. The KP4 structural inspections sought to determine whether dutyholders had an effective understanding of the state of their assets in the life cycle and whether they were, and would remain, fit for the remainder of their anticipated life.

Some dutyholders were developing ALE policies and procedures relating to structural issues, with one producing an ALE ‘Road Map’, which continuously reviews changes in deterioration mechanisms. In some cases, ‘Life of Field’ structural teams were being created, and structural analyses and cathodic protection (CP) requirements were being re-evaluated.
Other positive ALE initiatives on structural aspects included anomaly trend analyses being undertaken with the potential for data to be used to modify engineering codes, leading KPIs developed to provide early warning of catastrophic failure, and peer reviews in place to enhance understanding of structural performance.

Areas identified where dutyholders need to maintain ALE focus include:

- verification that structural analyses are happening during the same period and provide the necessary understanding of what is safety critical, to ensure the overall structural integrity is in keeping with Code target risk requirements;
- assessment, inspection and maintenance regimes which reflect operational history and experience, and hence potential future operational exposure at all stages of life;
- reassessment of the current and potential future failure and deterioration mechanisms;
- reassessment of barriers to failure to ensure they are suitable for ageing structures, and the anticipated remaining life of the installation;
- review of the continuing suitability of performance standards and operational controls;
- review of risks associated with uninspectable components;
- suitability allowances made for load and material variations given the potential consequences of failure (e.g., 10 000-year return event).

**Marine**

For FPSOs and mobile drill units (MoDUs), an effective marine integrity management system is fundamental to the safety of the entire asset. The KP4 marine inspections were seeking evidence that dutyholders had a good understanding of the integrity of the existing structures and effective inspection programmes, and were able to trend degradation rates to anticipate unsafe conditions and put in place effective repair and maintenance regimes.

The inspections found that policies for structural and marine integrity of floating assets are in place, and ALE KPIs and dashboards are being developed. Structural modelling and real-time monitoring were in place. The five-year inspection programmes and dry docking required by the Classification Societies for hulls and marine systems are well defined and in keeping with the aims of managing ALE.

For MoDUs there was long-term planning for equipment replacement and all dutyholders were using high-level risk matrices with responsibilities allocated to specific functions. There was good workforce involvement, ensuring a broad basis of knowledge input to AIM. The Marine Superintendent was normally a staff position.

Areas identified where dutyholders need to maintain ALE focus include:

- quantitative rejection criteria for marine SCEs;
- use of reviews and audits to feed trend analyses to develop long-term maintenance planning tools and systems;
- inspection programmes for secondary marine systems.

**Pipelines**

Offshore subsea pipelines are the arteries of the oil and gas industry and failure to manage ageing and degradation mechanisms could result in risks to platform personnel, environmental damage, and costly replacements.
The KP4 pipeline inspections sought to establish whether dutyholders had a thorough understanding of the potential degradation mechanisms and had effective control measures in place for ALE.

It was found that dutyholders had well-established, risk-based pipeline integrity management systems. In response to KP4, they were introducing ALE considerations into corporate AIM policies, with a view to incorporating more detailed ALE elements into the more specific pipeline technical policies and procedures, and that ALE standards and guidelines were being developed.

The inspections established that pipeline validation projects had started to provide a firm technical basis for ensuring pipeline integrity up to the ending of production. There were also reviews of the ageing issues around flexible risers. It was found that the pipeline life extension process was becoming an integrated part of the normal integrity management review process.

Areas identified where dutyholders need to maintain ALE focus include:

- ensuring audit frequencies comply with the Major Accident Prevention Document (MAPD);
- when a pipeline approaches or exceeds its nominal design life, dutyholders should reassess, record and validate the basis for continued safe operation;
- pigging frequencies should match the designated KPIs to aid both water displacement and corrosion management;
- intelligent pigging frequencies should be reviewed rigorously in conjunction with the identified degradation threats and other available intrusive and non-intrusive corrosion and inspection data;
- while challenging, operators found it beneficial to review and implement new technologies for internal inspection to validate condition monitoring assessments.

Identifying and sharing good practice

KP4 aims to encourage a culture of sharing and learning of good practices across the industry to deliver improvements in ALE. Catalysed by KP4, OGUK has developed an ALE Steering Group which has developed Management Guidelines* and tasked Electrical and also Floating Production Installation work groups to develop ALE guidelines. The Energy Institute is also developing a gap analysis of ALE publications and documents.

OSD is updating Offshore Information Sheet 04/2009 and is working with OGUK to develop ALE guidelines and good practices.

This work is in its infancy, and much more needs to be done, but as more information emerges from the KP4 inspection programme further activities to capture and disseminate these learnings will be developed.

Workforce involvement

Part of the KP4 strategy is to ensure the workforce is appropriately involved in ALE issues, as encouraging the workforce to have an understanding and appreciation of the importance of ALE is an important aspect for identifying issues for consideration within the ALE system.

* HS073 - Guidance on the Management of Ageing and Life Extension for UKCS Oil and Gas Installations, Issue 1, April 2012
Some dutyholders have organised ALE awareness workshops for the workforce to raise the profile, which has included offshore platform presentations, and question and answer sessions. KP4 is engaging with OGUK and SCiS to enable more formal workforce involvement, including a Step Change Safety Representatives Event planned for late November 2012. Other planned work with Step Change includes KP4 presentations to the Step Change Technical Authorities sub-group and at the Step Change Leadership Team.

The Offshore Industry Advisory Group (OIAC) sponsors the Workforce Involvement Group (WIG), which will also be considering ALE issues. WIG consists of representatives from the regulator (HSE), offshore safety representatives and installation managers, trade unions, employers and industry associations.

However, more innovative work is required across the industry to involve the workforce in this issue which is vital to everyone’s long-term future.

**KP4 to end of programme, December 2013**

KP4 is due for completion in December 2013, by which time ALE management practices will have been sampled across most dutyholders in the UKCS. At the same time, activities to identify and develop good practice guidelines should be well underway and some initial guidelines published. Events to encourage workforce involvement should equip everyone across the industry with an appreciation of the importance, challenges and way ahead for managing ALE.

By December 2013, all dutyholders will have been inspected and should have developed, and be implementing, long-term installation plans. The next phase of the programme will then review the implementation of these plans, particularly the commitment of senior management to provide resources and expertise to maintain the integrity of their installations.

Ageing is a global offshore issue, and HSE OSD will continue to learn from other parts of the world to share good practices across the North Sea and help play its part in maintaining a safe and viable offshore industry.
Further information

For more information, and for previous programme reports, see www.hse.gov.uk/offshore/programmerreports.htm

This document, and more information on KP4, can be found at: www.hse.gov.uk/offshore/ageing.htm