CORROSION MANAGEMENT OFFSHORE – RESOLVING THE PROBLEMS AND COMPLYING WITH THE LAW†

Andrew Duncan
Specialist Inspector, Corrosion & Materials, Offshore Division, Hazardous Installations Directorate, Health and Safety Executive

This presentation will look at the findings of the Health and Safety Executive’s (HSE) Key Programme 3 (KP3) Asset Integrity report, the interim findings of the HSE’s External Corrosion Project (ECP), and the offshore industry’s response to the challenges.

The laws on plant maintenance and integrity are based upon prevention and risk assessment, this, combined with a pool of world class expertise in corrosion management in the offshore oil & gas industry should mean the corrosion challenge is well managed. Despite this, materials corrosion and degradation have been a significant cause of hydrocarbon leaks, and, up to 2005 there was a rising trend of corrosion-related hydrocarbon releases against a general downward trend in overall leak frequency, including one corrosion related leak which resulted in the deaths of two men in 2002.

Some 30% of offshore hydrocarbon releases are due to corrosion and materials degradation. A review of the release statistics suggests that for every one perforation due to external corrosion there are about five perforations due to internal corrosion.

UK LEGISLATION RELATING TO OFFSHORE INTEGRITY

The presentation will discuss the Oil & Gas UK’s Corrosion Management Work Group’s new document: “Guidance For Corrosion Management In Oil And Gas Production And Processing” (Ref.: Energy Institute May 2008), and the “Corrosion Threats Handbook” (Ref.: Energy Institute 2008) which were the successful outcomes of collaboration between the Energy Institute, Oil & Gas UK (O&G UK), The HSE, offshore operators and consultants. The latest developments of the Work Group’s new “External Corrosion Management Guidelines” document will be introduced.

There are a number of areas of legislation relating to offshore integrity management, which includes the following1.

HEALTH AND SAFETY AT WORK etc. ACT 1974

Section 2: General duties of employers to their employees – it shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees.

Section 3(1): It shall be the duty of every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety.

KEY PROGRAMME 3 FINDINGS

Between 2000 and 2004, HSE’s Offshore Division (OSD) ran a major Key Programme (KP3) aimed at reducing hydrocarbon releases and focusing on the integrity of process plant. This resulted in a considerable reduction in the number of major and significant hydrocarbon releases. During this time, however, OSD became increasingly concerned about an apparent general decline in the condition of fabric and plant on installations and responded with Key Programme 3 (KP3) directed more widely at asset integrity, and scheduled to run between 2004 and 2007. KP3 involved targeted inspections of nearly 100 offshore installations representing about 40 per cent of the total (Ref: HSE 2008).

The KP3 report defined Asset Integrity as the ability of an asset to perform its required function effectively and efficiently whilst protecting health, safety and the environment.

Essential for the integrity of any installation are the safety-critical elements (SCEs). These are the parts of an installation and its plant (including computer programmes) whose purpose is to prevent, control or mitigate major accident hazards (MAHs) and the failure of which could cause or contribute substantially to a major accident. KP3 focused primarily on the maintenance management of SCEs, i.e. the management systems and processes which should ensure that SCEs would be available when required.

The inspection programme was structured using a template containing 17 elements covering all aspects of maintenance management, and a number of SCE systems tests. An element covering ‘Physical State of Plant’, was also included allowing the inspection team’s judgement on the general state of the platform to be recorded.

It was the element on the physical state of plant which led to significant concern by the HSE, and resulted in the HSE including asset integrity as a main priority for the future. This element was based on the inspection team’s opinion of the overall condition of the installation i.e.

†Crown Copyright 2009. This article is published with the permission of the Controller of HMSO and the Queen’s Printer for Scotland.
including fabric, structure, safety-critical and non-safety critical plant and systems. The data shows that over half of those reported (58%) were scored amber or red (Figure 3). Arising out of this area of concern was the widespread poor condition of offshore assets’ fabric maintenance, including gratings, hand rails, wind walls, external surfaces of process plant, nuts and bolts, valves, etc.

OIL & GAS UK
HSE held discussions with O&G UK to express our concerns about the condition of offshore production facilities leading to an agreement of the concerns and a way forward to improve the situation.

In response to the HSE’s concerns, the O&G UK’s Industry Integrity Work Group (IIWG) set up a Corrosion Management Working Group (CMWG) to generate new guidelines for corrosion management, and also a corrosion threats handbook. The working group included representatives from operators, regulators, verification bodies and service providers. The starting point for the work was the existing HSE research report written by CAPCIS ltd for the HSE in 2001 “Corrosion Management for Offshore Oil and Gas Production” (Ref.: HSE 2001).

A recent review by the HSE of the offshore industry’s response to the KP3 report has found that overall the industry had allocated considerable resource and effort to improve offshore assets and comply with required standards, and that the offshore industry leadership has responded well. There was evidence of good progress in addressing the issues identified by the KP3 work. However, the review also found that the work is by no means complete and continued effort is necessary to sustain the momentum of improvement initiatives, so that facilities are not allowed to degrade to the unacceptable levels identified in the 2007 KP3 report (Ref.: HSE 2009).

The review highlights that offshore safety and the security of UK energy supply depend on successful management of oil and gas asset integrity. It stresses as essential that fluctuating economic environments should not slow progress on management approaches to achieve and sustain the improvements KP3 emphasised as necessary.

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Reg #</th>
<th>Subject</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management of Health and Safety at Work Regulations 1999</td>
<td>3</td>
<td>Risk Assessment</td>
<td>Every employer shall make a suitable and sufficient assessment of (risks)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Principles of prevention to be applied</td>
<td>(preventive and protective measures)</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Health and safety arrangements</td>
<td>(effective planning, organisation, control, monitoring and review of the preventive and protective measures)</td>
</tr>
<tr>
<td>Prevention of Fire and Explosion, and Emergency Response on Offshore Installations Regulations 1995</td>
<td>4</td>
<td>General duty</td>
<td>(protect persons on the installation from fire and explosion)</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Assessment</td>
<td>(evaluation of risks and consequences)</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Prevention of fire and explosion</td>
<td>(prevention of fire and explosion)</td>
</tr>
<tr>
<td>Provision and Use of Work Equipment Regulations 1998</td>
<td>4</td>
<td>Suitability of work equipment</td>
<td>(work equipment shall be suitable for purpose)</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Maintenance</td>
<td>(work equipment shall be maintained in an efficient state, in efficient working order and in good repair)</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Inspection</td>
<td>(work equipment exposed to deteriorating conditions is to be inspected at suitable intervals and is safe to operate and any deterioration is remedied in good time)</td>
</tr>
<tr>
<td>The Pipelines Safety Regulations 1996</td>
<td>5</td>
<td>Design of a pipeline</td>
<td>(pipelines shall withstand the forces, fluids and chemical processes to which it is subjected)</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Access for examination and maintenance</td>
<td>(it shall be possible to inspect and maintain pipelines)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Materials</td>
<td>(materials of construction shall be suitable)</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Construction and installation</td>
<td>(pipelines shall be fit for purpose)</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Maintenance</td>
<td>(pipelines shall be maintained in good repair)</td>
</tr>
</tbody>
</table>
Asset Integrity is one of the four priorities within the current OSD plan of work (leadership, competence, asset integrity and safety culture). It will remain a key priority within interventions dealing with major hazard risk management, particularly in the light of the ageing infrastructure.

CORROSION MANAGEMENT WORKING GROUP, ABERDEEN
In response to the concerns raised by the HSE about the condition of offshore assets, the HSE got together with the Energy Institute, UK Oil & Gas, production operators and service suppliers to form a Corrosion Management Working Group. The aims of the CMWG were to produce contemporary guidance on the management of corrosion for offshore facilities, and resulted in May 2008 in the publication by the EI of the document: “Guidance For Corrosion Management In Oil And Gas Production And Processing” (Ref.: Energy Institute May 2008), which should set the bench mark against which operators should manage the degradation of both safety critical and non safety critical elements offshore. This document is published and available from the Energy Institute. The corrosion management system is based upon the HSE’s management model HS(G)65 (Ref.: HSE 1997) (Figure 4).

In tandem with the detailed guidance document the CMWG also developed a Corrosion Threats Handbook (Ref. Energy Institute 2008) in A5 format with waterproof pages, which shows in predominantly pictorial format the location of corrosion threats to offshore process plant and the damage morphology. This document is also published and available from the Energy Institute.

STEP CHANGE IN SAFETY
The Step Change In Safety organisation (www.stepchangeinsafety.net) have responded to the asset integrity concerns, and have delivered Asset Integrity workshops to 25 Operator and Contractor organisations with more planned for 2009.

Figure 1. Offshore corrosion leaks, 1995 to 2005

Figure 2. The perforated drain line which resulted in the death of two men

Figure 3. KP3 traffic light findings of physical condition offshore
The Asset Integrity Toolkit, originally published by UKOOA in 2006 (Ref.: UKOOA 2006) has been updated and will be released as a Step Change document in 2009. There is useful integrity management guidance and information on their website.

EXTERNAL CORROSION PROJECT

INTERIM FINDINGS

The HSE’s external corrosion project (Ref.: Whewell, February 2009) continues to highlight evidence that KP3 lessons still need to be fully adopted by the offshore industry.

The KP3 Report in 2007 identified a number of key lessons for the UK offshore industry. HSE subsequently targeted some of its work on these issues through two intervention projects, one on Corrosion Management and the second on Verification. The two projects have focused on production installation duty holders and plan to be completed by March 2010. The HSE has recently given feedback about emerging findings to the offshore industry via the Step Change Asset Integrity Steering Group and the O&G UK Health & Safety Forum.

EXTERNAL CORROSION MANAGEMENT PROJECT

KP3 identified the need for operators to better understand the potential impact of degraded, non-safety critical plant and utility systems on safety-critical elements in the event of a major accident. The purpose of the external corrosion project has therefore been to assess whether duty holders have effective maintenance management systems for components such as walkways and stairways; piping and pipe supports; cable trays and fittings; bolts, flanges & valves for both safety critical and non-safety critical applications. Of the platforms inspected the following summarises the key issues identified to date:

- **Physical condition:** the physical condition of installations visited during this project so far vary significantly, from good to poor, with some installations degraded to such an extent that major ‘upgrade projects’ are either planned or being implemented to address the situation. In six out of twenty two assets visited, a combination of poor physical condition combined with a failure to demonstrate
effective management of the situation has resulted in the serving of Improvement and Prohibition Notices (Figures 5 and 6); the PN resulted in the platform having to be shutdown.

At the time of writing, Figures 3 and 7 show that the percentage of reds for physical condition continue to run at about the same rate for KP3 and the external corrosion project.

Figures 8 to 19 show photographs taken during KP3 and the external corrosion project from a range of installations.

**Performance standards:** few of the duty holders inspected use measurable acceptance criteria for external corrosion of items such as gratings, bolts, cable trays, valves and continue to rely upon subjective decisions by inspectors. To rectify this the CMWG’s guidance document (Ref.: Energy Institute, May 2008) contains sections on rejection criteria. It is anticipated that duty holders will follow these guidelines.

---

**Figure 6.** Traffic light criteria

<table>
<thead>
<tr>
<th>Traffic Light</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>NON COMPLIANCE / MAJOR FAILING</td>
<td>Non-compliance with legislation</td>
</tr>
<tr>
<td></td>
<td>Major failing of system (hardware or management); or</td>
</tr>
<tr>
<td></td>
<td>Partial failure with a history of failure</td>
</tr>
<tr>
<td></td>
<td>MINDED TO SERVE A NOTICE</td>
</tr>
<tr>
<td>ISOLATED FAILURE / INCOMPLETE SYSTEM</td>
<td>Isolated failure of a well-defined system</td>
</tr>
<tr>
<td></td>
<td>Incomplete procedures/systems.</td>
</tr>
<tr>
<td></td>
<td>RECOMMENDATIONS IN THE LETTER TO DUTY HOLDER</td>
</tr>
<tr>
<td>IN COMPLIANCE / OK</td>
<td>Tested or inspected but with no significant issues found</td>
</tr>
<tr>
<td></td>
<td>Complies with regulations, etc.</td>
</tr>
<tr>
<td>NOT INSPECTED</td>
<td>Not tested or no evidence</td>
</tr>
<tr>
<td></td>
<td>There are concerns or information is unclear - re-inspect at later date</td>
</tr>
<tr>
<td></td>
<td>Issues in this category should include an explanatory note</td>
</tr>
</tbody>
</table>

**Figure 7.** Interim traffic light findings of the external corrosion project

**Figure 8.** Severely corroded hand rail, supported by scaffolding pole

**Figure 9.** Flow meter sender unit bracket corroded away
Corrosion strategies: all the duty holders inspected so far have corrosion strategies in place. However, these focus on safety critical plant & equipment with very few effectively recognising and addressing safety related plant and equipment. Sometimes this was exacerbated by poorly defined roles and responsibilities which failed to clearly identify the individuals responsible for maintenance of safety related plant & equipment.

Maintenance plans: the general focus of maintenance plans is on safety critical plant & equipment, with variable duty holder approaches to safety related plant & equipment, sometimes only addressing this issue at a local level with low priority.

Independent audits: the majority of duty holders have not undertaken independent audits of their corrosion management system. HSE considers that such audits should cover both the safety critical and safety related aspects to ensure the full and effective integration of both into the corrosion management system.

Failure & incident investigation: few duty holders effectively investigate to determine the root cause of failures of safety related plant and equipment. One reason for this may be the complexity of the techniques currently used. The CMWG’s guidance document (Ref.: Energy Institute, May 2008) provides a simplified technique to resolve this issue.

Figure 10. External and internal condition of deluge systems from different platforms

Figure 11. Vibrating line worn by guide

Figure 12. Deck lighting held in place by scaffolding pole and wire because bracket has corroded away
Key performance indicators (KPIs): a finding of the project is that the management of corrosion could be more effective by the use of further KPIs, particularly for safety related plant & equipment. The CMWG’s document (Ref.: Energy Institute, May 2008) provides a number of appropriate KPIs, and in addition the CMWG is currently developing further industry guidance to supplement this information.

Offshore workforce awareness and participation: although most duty holders encourage offshore workers to report corrosion concerns through their internal reporting arrangements, few are actively carrying out corrosion awareness programmes for their offshore workers.

It is concluded that most operators have good processes and procedures in place for asset integrity, however due to years of neglect many platforms are in a poor condition which will take a considerable time and considerable funds to rectify. It is evident that most operators are investing the required effort and funds to rectify the offshore situation and are responding positively.
REFERENCES


Whewell, I. February 2009, Head of HSE’s Offshore Division; extracts adapted from letter from I. Whewell to Oil & Gas UK.

HSE, 2009, KP3 Review, follow up to the 2007 findings.

OTHER POTENTIAL REFERENCE SOURCES

Offshore Technology, 18/11/2008, KP3 a year on – has the storm turned?


HSE, 13/08/2008, HSE concerned about continuing hydrocarbon releases offshore.


Figure 18. Severe nut and bolt corrosion on a gas riser ESDV

Figure 19. Total corrosion of a 4” diagonal support