Major Hazard (Asset Integrity) Key Performance Indicators in use in the UK Offshore Oil and Gas Industry

Bob Lauder – Health & Safety Policy Manager – Oil & Gas UK: CSB Meeting – Houston – 23 & 24 July 2012

Abstract:

This paper and the accompanying presentation respond to an invitation from CSB to describe major hazard key performance indicators (KPI) in use in the UK offshore oil and gas industry as part of CSB's effort to take learning from other oil and gas producing regions in support of post-Macondo improvement activities.
The paper provides an explanation of the main components of the UK KPI scheme and the part this scheme plays in providing reasonable assurance of the provision and maintenance of robust major hazard management measures. The paper also summarises the regulatory and operational context within which the KPI scheme functions; the mechanics of the scheme; its overall effectiveness; and identified areas for improvement. Finally, the paper offers responses to some specific questions on KPI arrangements raised by CSB as part of preparation for the public meeting.

The UK Offshore Oil and Gas Industry

To appreciate how the KPI scheme is structured and functions, it is useful to have an understanding of the UK offshore oil and gas industry.
Over 99% of the UK's oil and natural gas production is from offshore (source: DECC UK production data). Production of gas from the UK continental shelf (UKCS) began in 1967, with oil production starting in the 1975. Since then, over 40 billion boe have been recovered with the remaining recovery estimated to be between 14 and 24 billion boe (2011 Economic Report, Oil & Gas UK). The UK offshore oil and gas industry is of economic importance to the UK and provides energy security – in 2010 enough oil was produced from the UKCS to satisfy 87% (net) of the UK's demand for oil, with the figure for natural gas being 61% (source: Digest of UK Energy Statistics, 2010). There are currently 290 production installations on the UKCS; 170 being permanently manned installations and the remainder being Normally Unattended Installations (NUI).

UKCS Regulatory and Operational Context

On July 6th 1988, the Piper Alpha production platform exploded, killing 167 men and totally destroying the installation. The subsequent report of the Cullen Inquiry into the disaster delivered a series of recommendations including an overhaul of the regulatory regime to move from prescriptive to goal-setting legislation with major accident hazard management at the core of new legislation. Responsibility for safety regulation of the offshore oil and gas industry transferred from the Department of Energy to the newly formed Offshore Division of the Health and Safety Executive (HSE). A suite of new goal-setting safety regulations were introduced from the early 90's onwards; principal among these in relation to the KPI arrangements described in this paper are the Offshore Installations (Safety Case) Regulations (SCR), and the Offshore Installations (Design and Construction) Regulations (DCR). SCR introduced the requirement for major hazard assessment and for the identification and documentation of management system arrangements for the prevention and control of major accident hazards. DCR introduced the concept of safety-critical elements (SCE), those being legally defined as:

Such parts of an installation and such parts of its plant (including computer programmes), or any part thereof –

(a) the failure of which could cause or contribute substantially to; or
(b) a purpose of which is to prevent, or limit the effect of,

a major accident.

SCEs are typically grouped under the headings of Prevention, Detection, Control and Mitigation measures with some examples of each category shown in the table below.

Prevention	Detection	Control	Mitigation
▪ hydrocarbon containment ▪ ignition prevention ▪ structural integrity	▪ fire detection (flame & smoke) ▪ gas detection	▪ ESD system ▪ blowdown system ▪ subsea isolation valves	▪ firewater systems ▪ passive fire protection ▪ temporary refuge

The development and establishment of this regime remains fundamental to offshore safety on the UKCS with all installations having in place a safety case accepted by the Regulator. Major hazard management arrangements documented in the safety case include the requirement for a verification scheme to provide assurance that suitable SCE have been identified and provided, that they remain fit-for purpose, and are maintained in an operable and reliable condition to meet defined performance standards. The verification scheme is monitored and audited by an Independent Competent Person (ICP) appointed by the duty holder (installation Operator). All of those arrangements are in turn subject to regulatory scrutiny by HSE Inspectors. The main elements of major hazard management can be illustrated as per Figure 1 below.

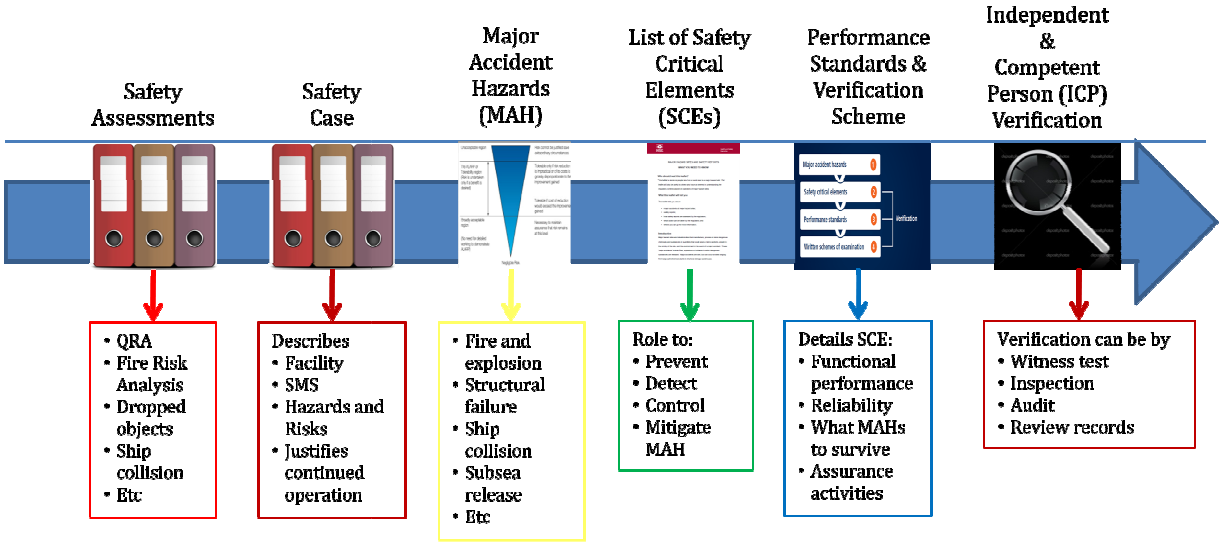

Figure 1: Summarised major hazard management process in use in UK offshore industry

This brief insight into the existing UK offshore major hazard management arrangements is essential as they provide the foundations of the KPI scheme described in the following sections of this paper.

KPI Scheme Origins and Evolution

The major hazard management arrangements described above have essentially been in place since 1992 when the Safety Case Regulations were first introduced. Those regulations undoubtedly transformed the UK offshore industry approach to hazard management and greatly increased the attention and effort applied to major accident prevention on offshore installations. Between 2004 and 2007 however, the regulator (HSE) conducted a focused programme of Asset Integrity inspections under the heading of Key Programme 3 (KP3). HSE defined asset integrity

as “the ability of an asset to perform its required function effectively and efficiently while protecting health, safety and the environment”. HSE further defined asset integrity management as “the means for ensuring that the people, systems, processes and resources that deliver integrity are in place, in use and will perform on demand over the asset’s life cycle”. Thus it can be suggested that what we call “asset integrity” is comparable to what is also referred to in major hazard industries as Process Safety.
KP3 was something of a wake-up call for the industry and the Regulator as it revealed shortcomings in asset integrity management that had hitherto remained undetected despite the robust major hazard regulation in place in the UK offshore industry. Among the many findings of KP3 was the fact that the industry did not have reliable key performance indicators in place that would focus attention on asset integrity measures and provide reasonable levels of assurance that major hazard management arrangements remained effective. Many duty holders had KPI in place at a company level but there was no cross-industry measurement effort and hence there was a lack of visibility of the general condition of asset integrity management at industry level.

A work group of technically competent people was set up with the remit of identifying suitable asset integrity KPI and developing a workable cross-industry scheme. Identifying relevant KPI that could be consistently and uniformly applied across a range of operating companies proved to be a significant challenge. A key consideration was the identification of subject areas for which companies would already have some monitoring and measurement processes in place, or could introduce with minimal effort. The existence of SCEs and mature verification schemes became obvious focus areas as did the recognition of loss of hydrocarbon containment as a significant risk contributor. After a number of iterations therefore, the following KPI were agreed upon and introduced fully in 2009:

- KPI-1 Hydrocarbon releases
- KPI-2 Verification non-compliance
- KPI-3 Safety-critical maintenance backlog

This offered a manageable and effective mix of related leading and lagging indicators as illustrated by Figure 2 below.

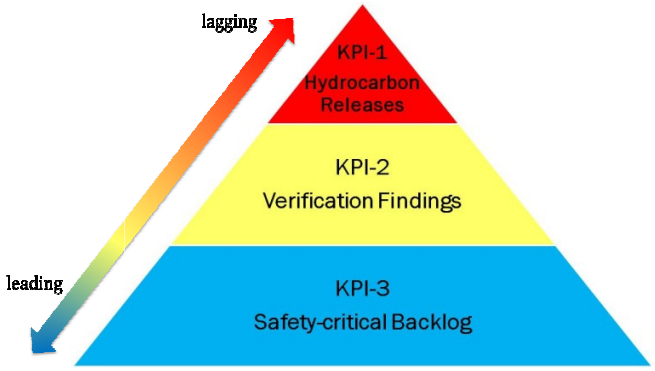

Figure 2: Representation of leading and lagging indicators used in UK KPI scheme

How the Scheme Works

The KPI scheme remains voluntary and currently has 21 participating companies providing data that covers over 80% of all UKCS installations. That level of engagement also means that we have coverage of the spectrum of offshore installations in terms of age, size and type (old, new, fixed, floating, NUI etc.). Data are submitted by participating companies to Oil & Gas UK on a quarterly basis and OGUK staff prepare a composite report across the range of indicators. Quarterly meetings chaired by Oil & Gas UK are held to review the data. These meetings are attended by company personnel involved in Verification and Maintenance management. Companies also make use

of industry KPI to benchmark their performance against industry peers although it must be stressed that this is not the intended purpose of the scheme. Since 2011 these KPI have also featured in the HSE (Regulator) annual offshore safety statistics bulletin which is in the public domain, giving greater transparency to industry major hazard management performance.

The KPI Scheme in Detail

KPI-1 Hydrocarbon Releases

There is a regulatory obligation on companies to report certain hydrocarbon releases (HCR) to the Regulator (reporting criteria are well defined and well understood) and a voluntary scheme to provide additional information about HCR. This reporting regime provides the raw data for KPI-1 and releases are categorised as minor, significant or major; again in relation to well defined reporting criteria. The tracking of HCR performance pre-dates the KPI scheme and records are available from 1996. The existence of HCR data meant that it was ideally suited for adoption as a lagging indicator on a number of counts, namely; the recognition of HCR as a major risk contributor; the regulatory requirement to report HCR events; the existing voluntary scheme to report HCR that would normally fall outside the regulatory reporting range; and the historical record allowing performance trends to be monitored from the outset.
Figure 3 below shows HCR performance to the end of 2011. Without going into detail in this paper, the graph shows significant improvement over the tracking period. At the end of 2010, the industry recognised a need to set an aggressive HCR reduction target and to focus additional effort on achieving that target. In the baseline year 2009/10 the industry recorded a total of 187 releases and a three year target of 50% reduction against that number was agreed. At the end of year two, the industry is on track to achieve the total HCR reduction target. Crucially perhaps, the reduction in significant and major releases is also very encouraging.
Having this as an industry KPI undoubtedly focuses appropriate levels of attention on a key area of major hazard management. As something of an aside in relation to this paper, details on individual HCR reports naming Operators, installations, and type and quantity of releases is now published on the Oil & Gas UK web site and is therefore in the public domain.

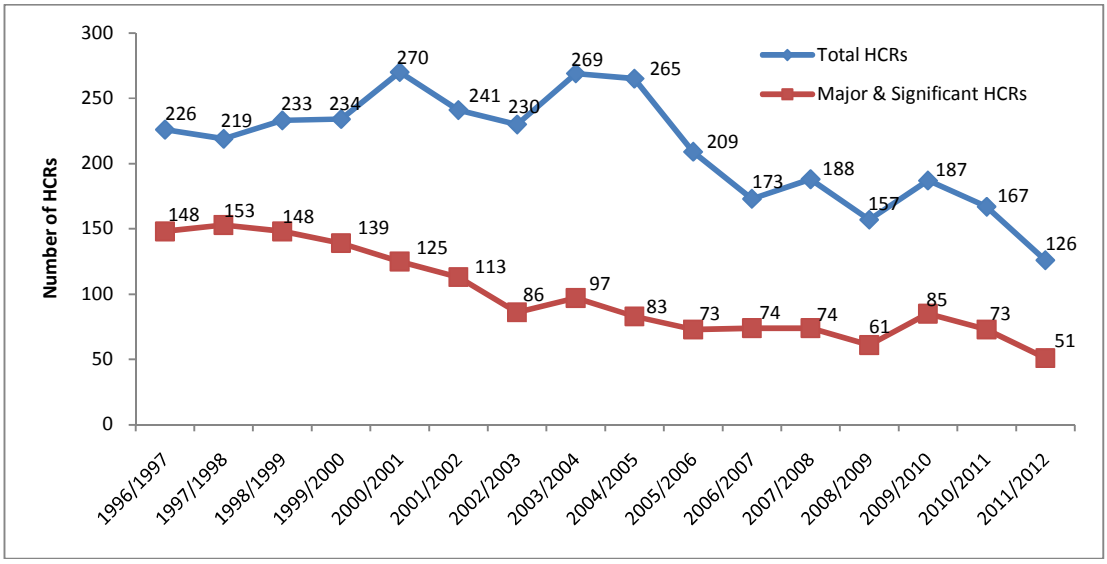

Figure 3: KPI-1 Hydrocarbon releases showing results trend over 16 year period

Information on hydrocarbon releases including detailed data is available on the Oil & Gas UK web site at:

http://www.oilandgasuk.co.uk/Hydrocarbonreleases.cfm

KPI-2 Level 2 and 3 Verification Findings

As described earlier in this paper, the Independent Competent Person (ICP) carries out surveillance of the Operator's verification scheme and reports on findings from monitoring and audit activities. ICP surveillance includes activities such as review of the Operator's inspection, maintenance and test (IMT) records for safety-critical elements, or actual witness testing of such IMT activity. ICP verification activity takes place both onshore and offshore. Given the role played by the verification scheme in asset integrity and major hazard management; negative verification findings are appropriate and effective KPI
The ICP uses a classification system to rank the criticality of findings as levels 1, 2, or 3 with level 3 being the most significant finding prompting the ICP to issue a letter of reservation or concern to the Operator. Although there are a number of verification bodies providing ICP services (principally Lloyds, DNV, Bureau Veritas and ABS), level 2 and 3 finding classifications are sufficiently aligned across the industry as to lend themselves to adoption as an industry KPI. Levels 2 and 3 findings are recorded and tracked separately to focus due attention on the more significant level 3 findings. The tracking also considers the overdue status of findings as an indicator of the effort applied to close out actions arising from negative findings.

Although considered to be a leading indicator, it could be argued that KPI-2 is on the cusp of also being a lagging indicator in that there has been some form of failure to cause the ICP to raise a level 2 or 3 finding. Given the normally accepted association of lagging indicators with some form of incident however, we are comfortable in considering KPI-2 to be a leading indicator.

Figure 4 below shows level 2 findings per installation per calendar quarter from 2009 to the end of 2011. It is not the purpose of this paper to interrogate or explain performance or trends but suffice to say that the integrity and maintenance management professionals who attend our quarterly meetings are typically comfortable with this level of performance particularly given that some of the findings may relate to administrative rather than hardware failings.

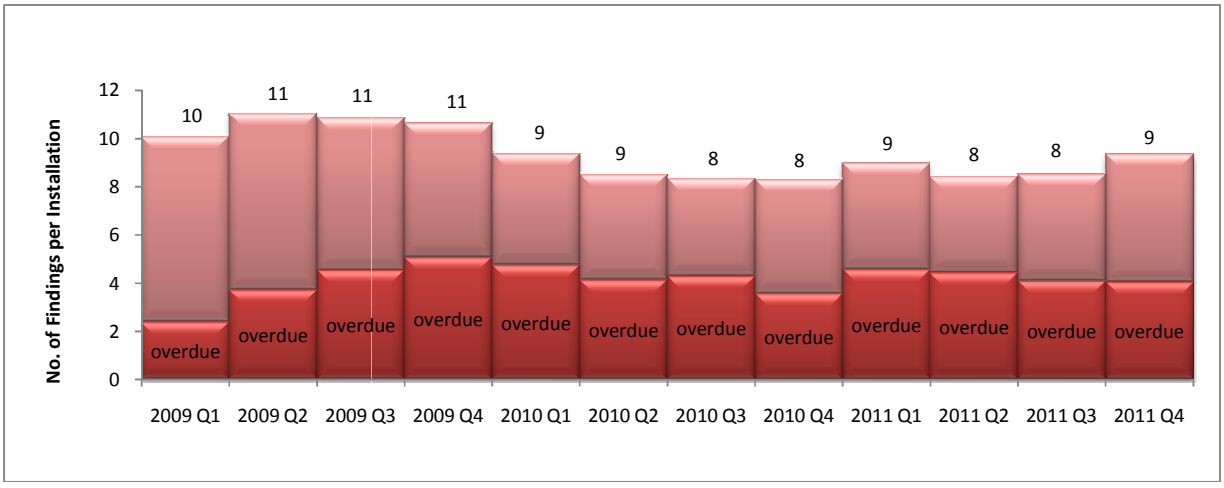

Figure 4: KPI-2 Level 2 Verification findings per installation per quarter over three year period

Figure 5 below shows the **total number** of level 3 verification findings across of the installations participating in the KPI scheme (>200 installations). Given that level 3 findings are at the high end of criticality, there is a realistic expectation that these will be few in number and hence they are measured as an industry total rather than per installation. Although as mentioned above this paper does not set out explain or justify performance as portrayed by KPI, the reduction in level 3 findings since 2009 is noteworthy.

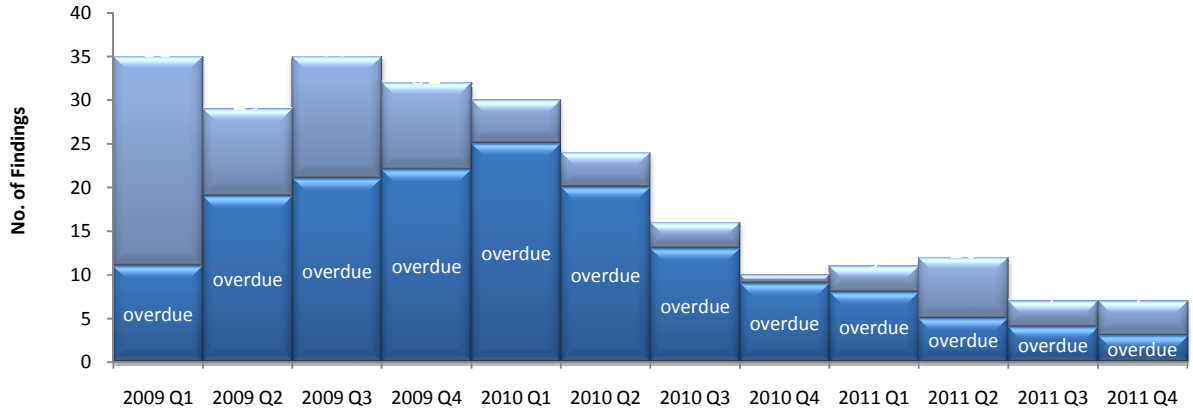

Figure 5: KPI-2 Level 3 Verification findings – total such findings across all installations within KPI scheme

KPI-3 Safety-critical Maintenance Backlog

Safety-critical maintenance is the inspection, testing and maintenance effort applied to ensuring that safety-critical elements remain in good order and continue to meet defined performance standards. This is central to effective and ongoing asset integrity and major hazard management and hence failure to complete such maintenance may compromise asset integrity. Key components of this indicator are backlog and of planned maintenance activities and deferred backlog.

Figure 6 below shows backlog of planned safety-critical maintenance expressed as total man hours per month per installation. This shows cyclic movement over the period but with no particular trend that helps explain those shifts. Again however it is the case that integrity and maintenance professionals who attend review meetings are comfortable with the level of planned maintenance backlog.

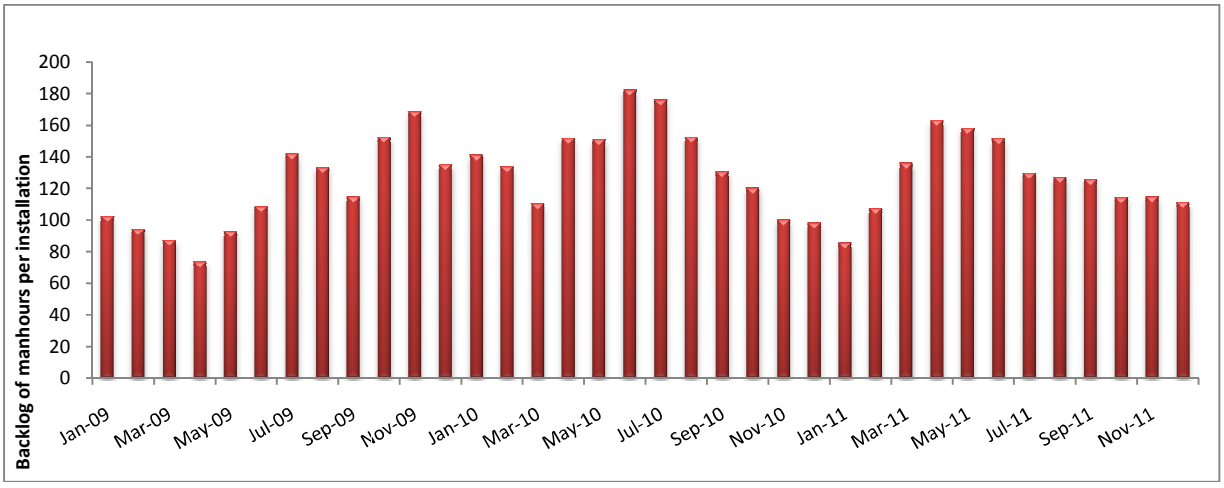

Figure 6: KPI-3 Backlog of planned safety-critical maintenance shown as total man hours per installation per month

Figure 7 shows deferred safety-critical maintenance again expressed as man hours per month per installation. Deferred maintenance activity is subject to a managed process of assessment to give assurance that deferral is acceptable from a safety perspective, and that the affected safety-critical element remains fit-for-purpose and will not become impaired by delayed maintenance activity. That deferral and the associated assessment process is preferable to having a backlog of planned safety-critical maintenance which could arguably be characterised as "work undone" or beyond its completion date. The increase in deferred maintenance shown in the chart at Figure

7 is evidence of an increase in the use of the deferral assessment process which might be seen as a welcome development from a risk management standpoint.

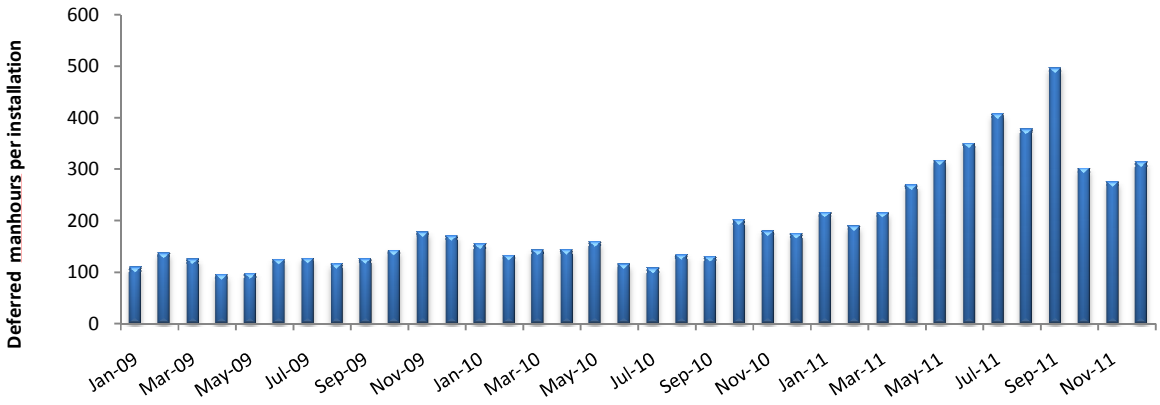

Figure 7: KPI-3 Deferred safety-critical maintenance shown as man hours per installation per month

Recent Modification to KPI-3

A recent review of KPI-3 highlighted that using man hours as the sole numerical indicator of backlog did not enable an adequate assessment of performance. Put simply, it is unclear whether say 100 hours of backlog is in fact good or bad. If it is 100 hours from a total work load of 1000 hours then that may be considered acceptable. If however, the 100 hours of backlog related to a total planned work load of only 200 hours that would be an entirely different picture and would clearly be unacceptable. We are now looking to show backlog as a percentage of total planned safety-critical maintenance man hours. Figure 8 shows how that will look using a small sample of total contributions for illustrative purposes. Data collection in 2012 has been modified to allow this calculation to be made in future.

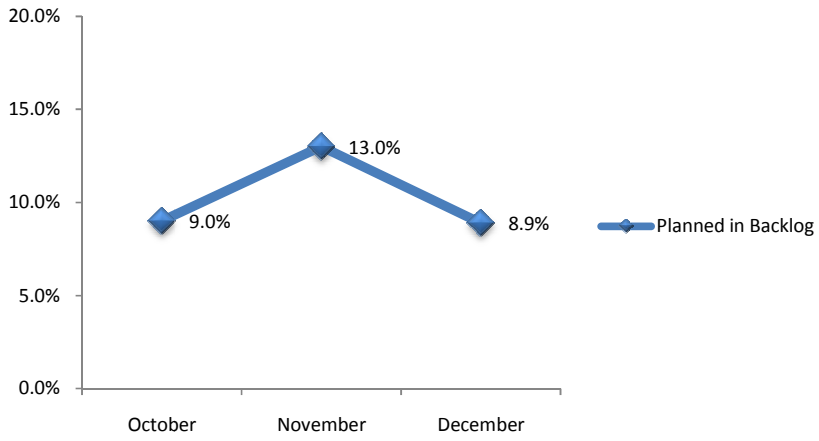

Figure 8: Level of deferred safety-critical maintenance shown as % of total planned man hours (sample only)

This adjustment will also allow the integrity and maintenance management professionals to agree on an acceptable or "target" level of backlog in % terms and to monitor deviations from the "target" level more rigorously than is currently possible.

Additional Enhancements to KPI Scheme

Although not strictly associated with the current leading and lagging indicators; we are now measuring independent and competent person (ICP) activity on an annual basis to provide some assurance that planned verification activity levels are being achieved. Given that the industry commits significant resource and financial expenditure to verification activities, it is appropriate to seek assurance that planned levels of activity are being maintained. Figure 9 shows percentage completion of ICP activity against planned levels. Given that much of the ICP activity takes place offshore and is therefore subject to operational and logistics constraints for example, the levels being achieved are generally felt to be acceptable. The next KPI review meeting is likely to discuss the apparent regression in ICP activity levels in 2011 shown in Figure 9.

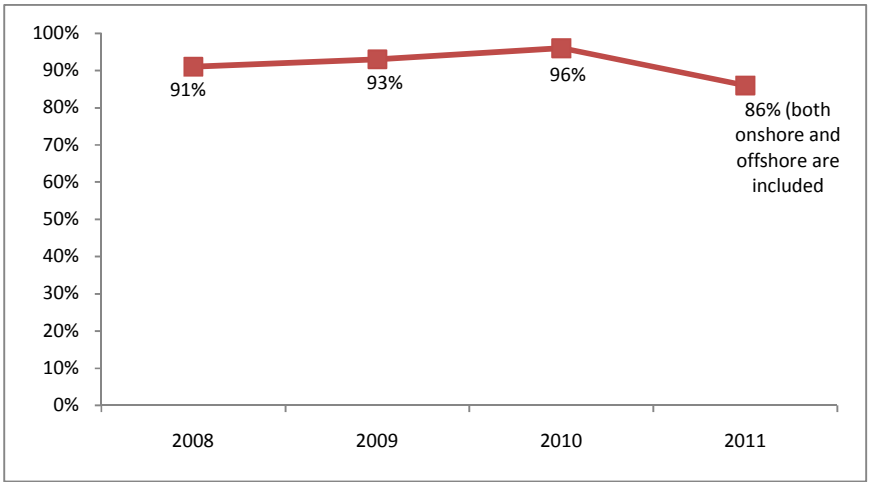

Figure 9: Percentage of independent competent person (ICP) activity completed vs. planned

Summary and Comment on Effectiveness of Scheme

After three full years of operating experience of the KPI scheme described in this paper, Oil & Gas UK and member companies are generally satisfied that it is successfully focuses attention on key elements of major hazard management. We are confident that the data provided by participating companies is reliable and consistent. That confidence is based in large part on the fact that the leading indicators relate to inspection, test and maintenance activities (packaged as assurance and Verification of safety-critical elements) that are required by legislation and are therefore subject to both ICP and Regulator scrutiny as well as company level controls. Equally, the lagging indicator of hydrocarbon releases forms part of a wider regulated incident reporting system with base input data in the form of reports managed by the Regulator (Health & Safety Executive). As described in this paper we have recognised some areas for improvement in the leading indicators and will make adjustments to those metrics during 2012.

It is difficult to comment with any certainty on the effectiveness of the scheme. We believe that the major hazard management arrangements that underpin the KPI scheme are in themselves robust and effective. To the extent therefore that leading indicators relate to those arrangements and cause senior personnel in the industry to reflect on issues such as safety-critical maintenance backlog, the KPI scheme must be seen to be fulfilling a useful purpose. The visibility within the scheme of a major risk contributor in the form of hydrocarbon releases; is also effective in terms of raising awareness and highlighting areas in need of additional effort and attention. That is evidenced by the current 50% reduction target and refocused HCR prevention efforts referred to earlier in this paper.

All of this said; we are now at a stage where clearly we have a need and an opportunity to take more intelligence from the KPI scheme rather than it being a data collection and review exercise. The quarterly review meetings are

being reshaped to be more interrogative of the information behind the data and to gain intelligence from the data; to identify areas for improvement and to share learning and experience between participating companies.

Responses to specific questions offered by CSB

As part of preparation for the Houston meeting, CSB forwarded some specific questions on the UK KPI scheme. These questions and Oil & Gas UK responses are set out in this section and hopefully complement other information set out in the paper to provide a comprehensive picture of the KPI arrangements in use in the UK offshore oil and gas sector.

Question: How do you define leading indicators? What advantage, if any, exists for using leading indicators? Does the data they provide have more / less / the same preventative impact than lagging indicators?

Response: We regard leading indicators as "input measurements" that look at areas of preventive effort applied to managing major hazards. Using the leading indicators provides some visibility to that proactive effort and offers a means of gauging the extent to which effort is maintained and is effective. Clearly leading indicators are designed to provide a health check of the major hazard management system and should highlight any areas of concern or in need of improvement effort before they cause or contribute to a major accident. To that extent it follows that leading indicators should have more preventative impact than lagging indicators, providing of course that any negative signals arising from the leading measures are heeded and responded to appropriately.

Question: How do you ensure that the indicators that you use are statistically significant?

Response: As mentioned earlier in this paper, the KPI scheme currently has 21 participating companies covering over 80% of all installations on the UKCS. That fact alone could be said to make it statistically significant. Additionally however, KPI-1 captures **all** hydrocarbon releases reported to the Regulator (i.e. not just those occurring on participating company installations). The scale of verification and safety-critical maintenance activities featured in KPI-2 and 3 is such that they can also be regarded as statistically significant.

Question: How has promotion and implementation of the 3 key performance indicators for major accident prevention been going? Successful? What challenges do you face?

Response: The extent of participation in the scheme suggests that it has been well promoted and successfully implemented. The inclusion of industry KPI data in the Regulator's annual statistics report for the first time in 2011 lends additional credibility to the scheme. Data submission is reliable although some participants do still require chasing occasionally. Attendance at review meetings is good and the meetings themselves are becoming more interactive. The main challenge we face is in keeping the scheme fresh and in particular in being able to gather better intelligence from the data. In addition to adjusting the data management processes (e.g. to show maintenance backlog as a % of total planned maintenance) we are making efforts to do more interrogation of the data in review meetings and to better understand what the data tells us. The intention is also to do more sharing of experience and learning at review meetings rather than just looking at numbers.

Question: How is the leading indicators programme going? Which companies or individuals are involved in its promotion?

Response: As referred to throughout this paper, the leading indicators element of the programme is generally going well although we are currently looking to improve aspects of those indicators. Participating companies are; Apache, BP, BHP Billiton, British Gas, Chevron, Centrica, CNR International, ConocoPhillips, Eni, Enquest, Maersk FPSO, Maersk Oil, Marathon, Nexen, Perenco, Petrofac, Shell, Talisman, Taqa, Total and Wood Group. Note that Exxon Mobil did participate but have recently sold their operated UKCS assets to Apache. Individuals involved in the scheme are typically maintenance or integrity management managers or senior engineers.

Question: There is the impression that industry may have a fear of publicizing their data - how can openness be elicited from industry? Why is industry in the UK North Sea now voluntarily reporting data to a greater extent than in the past?

Response: It is perhaps understandable that we would give the impression of being reluctant to publicise data in relation to major accident hazards as historically our published statistics have focused primarily on personal injury events. Oil & Gas UK on behalf of its members has also published data on what are referred to as Dangerous Occurrences; these are a range of events that are prescribed as being reportable to the Regulator and many such occurrences would also be classified as major accident hazards (and in some cases are actual major accidents). Again however, we have historically published composite data at an industry level without naming individual companies. During 2011 the UK oil and gas industry moved towards greater transparency of data in two significant areas, namely; the publication of asset integrity KPI data described in this paper in the Health & Safety Executive annual offshore safety statistics bulletin which is accessible on a public web site, and; the publication of detailed hydrocarbon release data on the Oil & Gas UK web site naming Operators and installations involved.
The recent move to greater transparency has been driven from the top of our industry and is part of a wider concerted effort to improve major accident hazard management as evidenced for example by the 50% HCR reduction target referred to in this paper. UK industry leadership agreed that in order to identify opportunities for shared learning and the adoption of good or best practice, we need to know more about HCR performance than just how many releases we have had. A secondary but nonetheless significant consideration is the fact that there is Freedom of Information legislation in place in the UK. That enables journalists for example to request access to detailed information on HCR reports in order to expose those who might be deemed to be "poor performers". Having had experience of that form of access and the distorted picture it is possible to represent from raw data, the industry now proactively publishes KPI and HCR data.
Oil & Gas UK has also published a 2012 Health & Safety Report which is the first of what will become an annual publication. Among other things the report provides information on industry safety performance including on hydrocarbon releases.

Relevant Reference Sources

1. Oil & Gas UK Health & Safety Report 2012
http://www.oilandgasuk.co.uk/cmsfiles/modules/publications/pdfs/HS074.pdf

2. Oil & Gas UK Knowledge Centre – Asset Integrity
http://www.oilandgasuk.co.uk/knowledgecentre/AssetIntegrity.cfm

3. Oil & Gas UK Knowledge Centre – Hydrocarbon Releases
http://www.oilandgasuk.co.uk/Hydrocarbonreleases.cfm

4. Health & Safety Executive guidance on Process Safety Indicators
http://www.hse.gov.uk/pubns/books/hsg254.htm

5. OGP Recommended Practice on Process Safety Key Performance Indicators
http://www.ogp.org.uk/publications/process-safety-recommended-practice-on-key-performance-indicators

6. Step Change: Assurance & Verification Senior Management Summary
http://www.stepchangeinsafety.net/knowledgecentre/publications/publication.cfm/publicationid/88

Contact Details

Bob Lauder blauder@oilandgasuk.co.uk