HSE

Health and Safety Executive

Key Programme 3

Asset Integrity Programme

A report by the Offshore Division
of HSE's Hazardous Installations Directorate

HSE

Health and Safety Executive

Key Programme 3

Asset Integrity Programme

Contents

Preface

This report has been produced to communicate the results and conclusions of the Asset Integrity Key Programme carried out between 2004 and 2007 by the Health and Safety Executive's Offshore Division.

The report is available on the HSE's Offshore Oil and Gas website at http://www.hse.gov.uk/offshore/information.htm. The traffic light matrix associated with this report can be downloaded separately as an Excel file.

Glossary

ALARP	As low as reasonably practicable
CAPEX	Capital expenditure
CEO	Chief executive officer
CRA	Corrosion risk assessment
ESDV	Emergency shutdown valve
FPSO	Floating production storage and offloading
FP	Floating production
HVAC	Heating ventilation and air conditioning
HSL	Health and Safety Laboratory
ICP	Independent competent person
IMT	Inspection management teams
IIWG	Installation integrity work group
IVB	Independent verifying body
KP3	Key Programme 3
KPI	Key performance indicators
MAH	Major accident hazards
MMS	Maintenance management system
NUI	Normally unattended installation
ORA	Operational risk assessment
OSD	Offshore Division
PS	Performance standards
QRA	Quantified risk assessment
RBI	Risk based inspection
RR	Research report
SPC	Semi-permanent circular
SCE	Safety-critical element
TA	Technical authority
TR	Temporary refuge
UKCS	UK Continental Shelf
UKOOA	United Kingdom Offshore Operators Association (now known as Oil and Gas UK Ltd)
WO	Work order

1 Executive summary

The offshore oil and gas industry on the UK Continental Shelf (UKCS) is a mature production area. Much of the offshore infrastructure is at, or has exceeded, its intended design life. Between 2000 and 2004, HSE's Offshore Division (OSD) ran a major programme KP1 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.

Asset Integrity can be defined as the ability of an asset to perform its required function effectively and efficiently whilst protecting health, safety and the environment. Asset integrity management is the means of ensuring that the people, systems, processes and resources that deliver integrity are in place, in use and will perform when required over the whole lifecycle of the asset.

KP3 involved targeted inspections of nearly 100 offshore installations representing about 40 per cent of the total. These included all types including fixed, manned and normally unattended installations, floating production (FP), floating production storage and offloading (FPSO) vessels and mobile drilling rigs. It involved all of OSD's Specialist and Inspection Management Team inspectors and all levels of management.

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, ie 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. The performance, on inspection, of each template element was scored using a traffic light system (explained in Appendix A2.5) which enabled overall installation performance to be recorded on a matrix. This in turn enabled an overview of company and industry performance to be obtained and examples of good and bad practice clearly identified. It was encouraging to find a number of examples of good and best practice and these have been shared with the industry and have also been included in the report.

The template and traffic light system has since been adopted by other National Regulators. Independent Verification Bodies, employed to verify the performance of SCEs on the UKCS, have also adopted the template and carried out independent inspections on behalf of dutyholders.

In the light of the findings from KP3, asset integrity will continue to be one of OSD's main priorities in 2008 and for the foreseeable future.

Main findings and lessons learned

The main findings and lessons learned from the Programme are:

Maintenance management systems

- The performance of management systems showed wide variations across the industry.
- There were often considerable variations in performance between assets in the same company as well as between companies.
- The state of the plant was often not understood because of the complexity of catagorising and recording equipment which was overdue for maintenance or found to be defective.
- Significant improvement in maintenance systems could be achieved without major capital expenditure by better planning, improved training and clear statement of performance standards in testing and maintenance routines.
- There is a poor understanding across the industry of potential impact of degraded, non-safety-critical plant and utility systems on safety-critical elements in the event of a major accident.
- The role of asset integrity and concept of barriers in major hazard risk control is not well understood.
- The use of operational risk assessments (ORAs) to compensate for degraded SCEs is often not well controlled.
- The technical authority role needs to be strengthened in many companies.
- The industry is not effectively sharing good and best practice. This is particularly evident in that companies were not learning the well-publicised lessons gained during the life of KP3.
- Cross-organisational learning processes and mechanisms to secure corporate memory need to be improved.
- Companies need to work better with verifiers using their collective skills and knowledge to aid improvement.
- Companies need better key indicators of performance available at the most senior management levels to inform decision making and to focus resources. Many management monitoring systems tend to be overly biased to occupational risk data at the expense of major hazard precursors.
- Many senior managers are not making adequate use of integrity management data and are not giving ongoing maintenance sufficient priority.
- There is a need for a common understanding and definition of maintenance backlog and the use of deferrals.
- Audit and review arrangements are not being used effectively to deliver organisational learning and continuous improvement.
- The KP3 template provides companies with a framework for improvement.

Overall condition of the infrastructure

- There is wide variation in the condition of hardware integrity across the industry dependent on installation design, CAPEX costs and subsequent investment.
- The main hydrocarbon boundary appears reasonably well controlled but supporting hydrocarbon infra structure such as valves, pipe supports continues to be in decline.
- The jacket and primary structural integrity is reasonably well controlled.
- In some companies the decline in integrity performance that started following the low oil price has not been effectively addressed and there appears to be an acceptance of this knowing that the assets are likely to be sold. This decline may hamper future field development and long-term sustainability.
- Declining standards in hardware is having an adverse impact on morale in the workforce.

- Skills shortages, long lead times for delivery of materials and equipment, bed space and availability of accommodation vessels are limiting the industry's ability to achieve rapid improvements.
- With suitable prioritisation and leadership real improvements in the condition of the infrastructure can be achieved.
- Insufficient full loop testing is carried out on Safety Critical Elements resulting in reduced levels of reliability of SCEs.

Findings on overall industry performance

In broad terms mobile rigs were found more likely to perform better than fixed installations. Meanwhile, fixed installations were found more likely to perform better than floating production assets.

The performance of installations in a number of elements of the maintenance management system was scored using a traffic light system.

The following aspects of the maintenance management system were found to be more likely to perform well:

- reporting to senior management;
- key company specific indicators of maintenance effectiveness;
- communications between onshore and offshore;
- supervision (ie confirmation that maintenance tasks have been completed in accordance with the instructions on the work order, time spent on the plant by supervisors etc);
- defined life repairs.

The following aspects were found to be more likely to perform badly:

- maintenance of SCEs;
- backlog;
- deferrals;
- measuring compliance with performance standards;
- corrective maintenance.

For more than 50 per cent of installations inspected the State of Plant element was considered to be poor. Companies often justified the situation with the claim that the plant, fabric and systems were non-safety-critical and a lower level of integrity was justified. This illustrates a lack of understanding in many parts of the industry that degraded non-safety-critical plant and utility systems can impact on safety critical elements in the event of a major accident reducing their performance.

The findings arising from the inspections of the specific safety-critical elements covered by the programme were more encouraging but TR HVAC, TR Doors and Deluge still gave significant cause for concern. These were key issues identified at the time of Piper Alpha.

Note: Where a 'red traffic light' was recorded which meant the inspector had identified a non-compliance with legislation, a major failing of a system (hardware or management) or partial failure with a history of failure then appropriate action was taken in line with HSE's enforcement policy.

Underlying issues identified as contributing to poor performance

- Leadership

Senior management set priorities between investment in field development, asset maintenance and profit on the basis of health, safety and financial risks. The findings indicate that the priority given to asset maintenance in the past has been too low. Whilst most senior management currently get information on certain aspects of maintenance performance such as backogs and deferrals this provides only a limited picture on SCE status. To better understand the relative priorities senior managers must improve their understanding of the safety and business risks arising from continuing to operate with degraded SCEs and safety-related equipment. This may require a simplification of the reporting arrangements for backlogs, deferrals, corrective maintenance, SCE performance etc and a clear understanding of the key performance indicators associated with asset integrity.

- The engineering function

A key element in balancing priorities is to ensure that the engineering function has sufficient authority to put forward the case for major hazard control and act as a backstop against degraded SCEs and safety related equipment and structure. The influence of the engineering function has, in many companies, declined to a worrying level. This may be partly attributable to changes in the structure of companies.

- Learning

KP3 has demonstrated that there is considerable variation in the performance of management systems and delivery of appropriate standards, across the UKCS and often in the same company. A significant factor in this is an underlying weakness in many companies' audit arrangements to ensure compliance with procedures. These are not being used effectively to share learning arising from the audits and to promote and learn best practise within the company and between companies. Improved arrangements for auditing and monitoring performance are needed in most companies.

Moreover, learning is not just achieved by identifying and sharing best practice, but also by having process to enable the learning to be embedded.

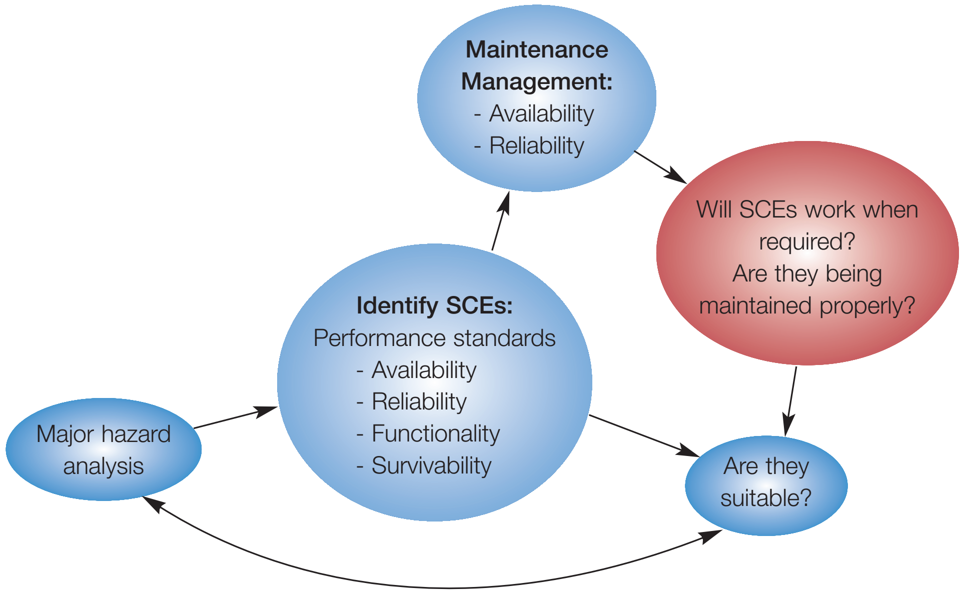
2 Introduction

Background

The offshore oil and gas industry in the UK Continental Shelf (UKCS) is a mature production area. Much of the offshore infrastructure is at, or has exceeded, its intended design life. During the 1990s low oil prices and initiatives to reduce costs led to a reduction in the offshore workforce. This in turn led to reductions in levels of maintenance and, as a result, an overall decline in the integrity of fabric, structures, plant and systems. The harsh operating environment on the UKCS has exacerbated the rate of degradation.

In 2000 HSE's Offshore Division launched a major programme KP1 aimed at reducing hydrocarbon releases and focusing in particular on process plant. This ran until 2004 and resulted in a considerable reduction in the number of major and significant hydrocarbon releases. During this time, however, the above factors, together with two fatalities in 2002 arising directly from integrity failure issues, served to reinforce concerns that the risk of major accidents on the UK continental shelf appeared to be rising. HSE therefore decided to initiate Key Programme 3 (KP3), Asset Integrity Inspection, which formally commenced in 2004.

The decision was made to focus the programme on the effective management and maintenance of safety critical elements (SCEs). These are the parts of an installation and its plant (including computer programmes) the purpose of which are to prevent, control or mitigate major accident hazards (MAH) and the failure of which could cause or contribute substantially to a major accident. The relationship between major hazards, development of SCEs and their maintenance management is shown below.



The SCEs represent the **barriers** which prevent, control or mitigate the major accident scenarios. The maintenance management strategy must be developed to provide assurance that they will be available when required, they will operate with the required reliability and they be able, as necessary, to survive incidents against which they are designed to protect.

The full background to the programme and overall aims and objectives of KP3 are described in detail in the KP3 Handbook and summarised in Appendix 1 and 2. The Handbook[3] gives a detailed account of the development of the programme. It can be found on the HSE's offshore oil and gas website address under Programmes of Work at: http://www.hse.gov.uk/offshore/kp3handbook.pdf.

As part of the overall KP3 Programme, HSE inspectors carried out onshore and offshore visits to nearly 100 installations and over 33 dutyholders.

The approach taken in KP3 of a coordinated programme of inspections with a common template has provided significant benefits. These include consistency of approach, and the collation and analysis of all reports by a central management group, enabling identification of common areas of good and poor practice across the industry. The most significant outcome has been the ability to report on an industry wide basis. This has facilitated engagement and been very effective in raising the profile of integrity management across the industry.

The analysis and conclusions are described in Sections 3 and 4 with the description of results contained in Appendix 3. Section 3 describes specific areas where performance has been found to be poor and common themes which have led to poor performance. It also identifies practices adopted by dutyholders which led to good performance. Several examples of general good practice are also given which, if adopted more widely, would assist in improving overall industry performance.

This report has been placed on HSE's offshore oil and gas website[4] at: http://www.hse.gov.uk/offshore/.

The results

For each inspection, the individual elements of the inspection template were given a green amber or red traffic light (see Appendix 2). These traffic lights were then transferred to a matrix from which a picture of overall industry performance could be built up (See Appendix 2.8.). The internet version of this report will also include a downloadable version of the numbered traffic light matrix at: http://www.hse.gov.uk/offshore/information.htm.

Individual companies have been provided with the information to be able to identify their platforms on this matrix and carry out their own analyses as required.

More detail on the analysis of the KP3 inspection reports and traffic light distributions is being prepared in a Health and Safety Laboratory (HSL) report[5]. When completed, this report will be available under Research Reports (RR) on HSE's website at: http://www.hse.gov.uk/research/rrhtm/index.htm.

Additional workstreams

In addition to the inspection activities parallel themes of work have been running as part of the overall programme. Improved communication and raised awareness of installation integrity issues was a key objective of the programme. This was achieved by participation in industry seminars and conferences and presentations to industry groups. These have included presentation to the UKOOA Asset Integrity Seminars in 2005 and 2006, regular presentations to the UKOOA Step Change Leadership Team, Process Managers Group and Installation Integrity Workgroup.

The latter group was set up by the industry as a direct result of KP3 and involved over 30 oil companies, contractor organisations and independent verification bodies. HSE took a full part in this workgroup. The group was set up to work at a tactical level to share information and develop tools.

The group developed the Asset Integrity Toolkit, which is a comprehensive guidance document describing industry good practice in SCE maintenance management. The toolkit also provides a basis for benchmarking performance in the future. The group also developed new Key Performance Indicators (KPI) in 2006[6]. The three KPIs developed are now being used to measure industry and company performance.

More recently the industry safety initiative 'Step Change' made an important strategic change in emphasis by forming a high-level influential Asset Integrity Leadership Team. The team has set itself a challenging agenda, describing asset integrity as the industry's biggest single challenge. HSE and industry will continue to work together to secure continuing improvement in the management of asset integrity on the UKCS.

3 Analysis of results

This section provides an analysis of the results derived from the KP3 inspection programme given in Appendix 3. The section is structured to give:

- an overview of the issues summarised in terms of management systems; hardware, system testing and communications;
- performance differences between mobiles, fixed and FPs;
- specific template element issues;
- supplementary factors affecting performance.

A view on possible underlying reasons for successes or failures is given in Section 4.

3.1 Overview of findings (Appendix A 3.1.1)

3.1.1 Maintenance management systems (Appendix A3.1.1)

Management systems covers:

- the structure of the maintenance system;
- definitions of backlogs, deferrals;
- competence to supervise and deliver the maintenance system;
- reporting and recording data;
- measuring the effectiveness.

Inspection of the maintenance management system has revealed both good and poor practice.

The structure and diversity of the maintenance management systems found offshore is often very complex. Measuring performance is difficult as the definitions for backlog, deferrals, overdue maintenance, corrective maintenance, safety-critical and critical often lack clarity. This makes it time-consuming for senior onshore managers to be absolutely clear on the size of the maintenance task at any one time and maintenance performance which can lead to poor management prioritisation. Add to this the task of inspection and verification and the levels of complexity rise. The variance in definitions across industry also makes it difficult to produce detailed performance indicators and benchmarking.

Management prioritisation is made more difficult when the companies have to balance maintenance requirements and upgrade proposals because there are severe bed space/resource constraints. More recently this issue has been increasingly recognised with tough commercial decisions being taken to enable maintenance backlogs to be addressed. However, there has been evidence of installations starting shutdowns with several hundred hours of safety-critical backlog and having carried out a tieback programme completing the shutdown with the deficit increased to several thousand hours safety-critical backlog.

A further issue has been that where safety-critical elements are degraded due to outstanding corrective maintenance there is a need to put contingency plans in place following operational risk assessments (ORAs). Some installations have been found to have very high numbers of ORAs in place at one time. In some cases these ORAs have little formal approval and onshore management have not been aware of the scale and scope of the contingency arrangements.

Poor performance in maintenance systems has been further exacerbated by a workforce that is depleted in experience. The pressures arising from shortages of competent manpower and skills have become severe over recent years. This issue impacts on all areas of SCE maintenance management. It has been given throughout the programme by many dutyholders as a reason for:

- high backlog;
- poor adherence to procedures;

- general management issues related to high staff turnover such as weak risk assessment and implementation of mitigation measures on SCE failure.

There is also a shortage of materials and pressure on onshore manufacturing facilities which frequently cannot deliver to realistic timescales.

A key onshore function that is not delivering its intended role is the Technical Authority responsible for evaluating and making engineering and other technical judgements on the safety and production implications arising from offshore operational issues. This appears to be due to several reasons including lack of resources, insufficient time spent offshore due to lack of bed space and inability to influence senior management. What is clear is that much needs to be done to strengthen this function and wider consideration needs to be given as to the role of the engineering function at senior levels in companies.

There were also many examples where senior onshore management received information on maintenance effectiveness based solely on indicators such as equipment downtime. Less frequently did senior managers receive analysis reports showing compliance of safety-critical element performance with safety case performance standards. Maintenance management systems have the functionality to provide such reports but often the quality of data is poor. The industry asset integrity team recognised this as an important issue and developed, in conjunction with the verifiers, a surrogate measure of major hazard safety, ie the number of 'anomalies' in tests of safety-critical elements, outstanding at the end of the month. The industry, however, has been slow to supply comprehensive data for this important leading indicator.

3.1.2 Performance of the maintenance management system

The overall inspection matrix clearly identifies areas of good and bad performance. The picture is very mixed with some elements showing improvement, some showing consistently poor performance and some consistently good performance over the past three years. There are also differences in performance between installation types which must be taken into account (see Section 3.2).

Just over 60% of traffic lights assigned were green. The 8% of red traffic lights assigned are considered to be the most significant issues with some involving formal enforcement action, usually in the form of an Improvement Notice. Ranking the assigned traffic light numbers highlights the areas of maintenance management where performance was most consistently good or bad.

Poor performance

The weakest management systems based on numbers of red traffic lights were Maintenance of SCEs, Backlog, Deferrals, Measuring Compliance with Performance Standards, and Corrective Maintenance.

Based on the number of ambers assigned, Maintenance Recording was ranked as the worst performer with Maintenance of SCEs second and Technical Supervision/ Competence (ie competence assurance of technicians and supervisors) third. Backlog was ranked fourth and Corrective Maintenance ranked fifth.

The issues related to Measuring Compliance with Performance Standards were similar to those of Maintenance of SCEs, ie poor risk assessment on SCE failure, lack of involvement of relevant technical resources in risk assessment and consideration of mitigation measures and an incomplete understanding of the status of SCEs.

The reasons for this poor performance are considered most likely to be due to:

- poor understanding of the function of SCEs as barriers to MAHs and ensuring that maintenance assures their functionality;
- absence of or, poor post maintenance function testing;
- failure to carry out risk assessment and implementation of mitigation measures on failure of SCEs;
- poor quality of procedures for deferral management and their implementation;
- high levels of corrective maintenance creating an impact on planned maintenance.

The issues are discussed in greater detail below in Sections 3.4 and 3.5.

Good performance

Overall, twice as many green traffic lights were assigned than amber and 7.5 times as many green than red. The five best performing areas were:

- reporting to senior management;
- key company specific indicators of maintenance effectiveness;
- communications between onshore and offshore;
- supervision;
- defined life repairs.

Preparation of reports on the maintenance system status and reporting to Senior Management were consistently the best performing areas. Information derived from the maintenance management systems in the majority of cases appeared to be clear and extensive. This must be qualified by the fact that maintenance management systems can contain large amounts of spurious data. This can obscure true levels of backlog and corrective maintenance. In addition, corrective backlog figures generally do not reflect the level of ongoing breakdown and repairs which are completed relatively quickly. In some cases maintenance crews operate in a 'fire fighting' mode due to high levels of breakdown which are not reported or made clear to senior management.

Key indicators for maintenance system effectiveness appear to be well recognised across the industry and in general companies are collecting and collating this data.

Day-to-day communication between onshore and offshore for technical and management support appears to be working effectively in the majority of cases. This has been facilitated in recent years by conference call facilities which are used extensively across the industry for daily morning meetings and calls. Generally, communication between offshore supervisors and maintenance technicians, with onshore Technical Authorities (TA) appears to be working well. It is essential that TAs are given regular access to their installations in order to strengthen their relationships with their discipline technicians and ensure familiarity with the plant and systems. Where problems have been found, they relate to the ability of TAs to carry out offshore visits regularly due to pressure on bed space from project work etc. As a result TA visits lose familiarity with the installation and this undermines their contribution to risk assessment.

Supervision is generally of a high standard. However, there are problems related to time available for supervisors to spend on the plant. This is reflected in the relatively high number of ambers scored. There are problems on some installations due to staff turnover but generally offshore supervision appears to be good in most cases. There is, however, a lack of lead technicians on many installations reducing the amount of monitoring of the quality of work for individual disciplines. As a result the only indicator of performance is an indirect one, the number of post maintenance breakdowns. Also, the detailed planning of all maintenance tasks and MMS data input checking falls to the Maintenance Supervisor, leaving him less time available for high level planning and walkabouts.

Management of defined life repairs was adequate in the majority of cases. Industry had focused on Defined Life Repairs after the Brent B tragedy which may account for the good performance in this respect. Some companies used defined life repairs for hydrocarbon lines and most were well documented. There were, however, examples of very poor use of the 'wrap' type of repair. There can be more uncertainty in inspecting such repairs making the detection of internal corrosion more problematical. Some companies have set a policy not to use defined life repairs for hydrocarbon lines to remove the uncertainty in the level of safety. This is a practical example of best practice and leadership in major hazards.

3.1.3 Physical state of plant (Appendix A3.1.2)

This section of the report discusses the physical state of the plant by giving an overview and then examples of specific issues and possible underlying reasons for poor performance.

This template element was based on slightly different criteria to others on the matrix. Whereas management system elements were related solely to SCEs, this element was based on the inspector's opinion of the condition of the installation overall ie including fabric, structure, safety-critical and non-safety-critical plant and systems. In the final year of the programme a guidance booklet was produced by OSD Corrosion Specialist Group[8]. It was intended to assist inspectors in making judgements about the condition of plant and improve consistency.

For more than 50 per cent of installations inspected the State of Plant element was considered to be poor. Companies often justified the situation with the claim that the plant, fabric and systems were non-safety-critical and a lower level of integrity was justified. This claim disguises a poor understanding across the industry of potential interaction of degraded non-safety-critical plant and utility system with safety-critical elements in the event of a major accident. In addition, as the scale of plant degradation increases the pressures on resources increases creating tensions between the need to remedy basic fabric problems and carry out repairs critical to integrity.

The human factor effects of the degradation of structures, hand rails, steps, gratings, piping, vessels, nuts and bolts on crew motivation, morale and their role in preventing major accidents, appears not to be properly understood or, ignored by senior management. Fabric maintenance is very poor on many platforms, showing inadequate long term planning by the operators for the lifetime of installations, a lack of regard for the working environment of offshore workers and the risks to the individual of injury. The poor condition of many platforms has increased the risks of injury to personnel from dropped objects, hand lacerations and falling through gratings.

High levels of project work, drilling programmes and ongoing problems related to ageing plant reliability have often put severe pressure on bed space. Painting teams will often be the first to be removed and it is now unusual to find painters employed full time on many installations. As a result, painting programmes have diminished or ceased with a corresponding increase in levels of corrosion.

Many companies have not employed inspection engineers permanently offshore over recent years. When combined with a lack of painting programmes, the subsequent high rates of corrosion have led to rapid deterioration, which has not been monitored or addressed. Where inspections have been taking place, a lack of onshore specialist corrosion resource has at times prevented data being analysed. Consequently coherent corrosion management programmes have not been developed and implemented. The result is a continual increase in inspection and corrosion problems which the industry is struggling to break through.

On the positive side, where there are defects in primary structure their extent is well known and documented and limited to very few installations. However, some installations had extensive corrosion to tertiary structure, eg cable tray supports, and some safety-related kit, eg fire doors, gratings and bulkheads. As indicated above, this type of corrosion, whilst not of immediate safety concern, sends an undesirable message to the workforce on lack of investment and undermines efforts to engage the workforce in health and safety.

Where Inspection Engineers have been employed offshore on a permanent basis, improved performance has been noted provided that resources are in place onshore to assess the data, formulate corrosion management plans and implement them. Many operators have introduced integrity management teams with access to senior management, who meet regularly to discuss corrosion issues and how they should be managed and to prioritise resolution of problems in accordance with the principles of risk assessment.

The introduction of corrosion risk assessment (CRA) and risk based inspection (RBI) has offered an opportunity for operators to apply sound corrosion science and engineering to the identification of potential problem areas and to target inspection in an intelligent and defined manner. The corrosion community has developed the methodology to a high level, providing innovative solutions to a complex and often stochastic process. The application of computer software to manage the risks and inspection of thousands of pipe lengths and dozens of pressure vessels has further improved the process.

Whilst CRA and RBI are good in theory, inspection programmes can fail to deliver the required performance due to lack of commitment by the company to provide onshore and offshore resources, and to free up bed space on the platform to enable the required number of inspectors to implement the plan.

Use of duplex stainless steels to manage harsh environments has not always gone well, with numerous incidents of internal and external stress corrosion cracking of topsides pipework, and hydrogen embrittlement. More rigorous testing and greater understanding of the performance envelope of duplex stainless steels appears to be required.

An additional factor over recent years has been the process of asset shedding. The installations involved have generally been seen as nearing the end of their production lives or, have fallen below what is considered financially viable in the business models of larger oil companies. As a result, levels of fabric maintenance had declined, often over several years before the disposal. The new dutyholders have found that the levels of integrity in relation to inspection and corrosion prevention are low and a significant amount of refurbishment work has been required. In addition, maintenance records have not been as extensive or comprehensive as expected at handover.

Design life extension is a major issue that also places an extra burden on the level of refurbishment required. Some companies have begun to address this situation by implementing policies such as spool replacement rather than temporary repair. It is encouraging to note that there are several major integrity improvement programmes ongoing now involving a significant financial commitment. Whilst these are to be commended it should not be forgotten that on their completion they will only bring back installations to the standards they could and should have been achieving with effective integrity maintenance arrangements.

3.1.4 Safety critical system testing (Appendix A3.1.3)

A successful test of the performance of the hardware is an indication that the management arrangements such as the maintenance system, the competence assurance programmes, and monitoring programmes are functioning. For example, when HSE carries out a test of the functioning of an HVAC damper there will have been maintenance and testing by the duty holder, and as part of the verification process the verifier will have arrangements to ensure that this maintenance and testing is delivering integrity. HSE tested only a sample of SCEs to ensure that there is not excessive overlap with the verifier. Of the 15 potential system tests, of which several were selected on each inspection, TR HVAC, deluge systems, fire pumps and ESD were most frequently tested.

TR HVAC Tests

TR HVAC systems were the most extensively safety-critical system tested. Despite considerable publicity at the UKOOA integrity workshops subsequent KP3 inspections revealed failures in HVAC dampers.

The Cullen Report into the Piper Alpha disaster[10] recommended that a TR should be provided on all offshore installations. The TR is required to have a defined performance standards related to its survivability, primarily against ingress of smoke (comprised of CO, CO_2 and hot soot), flammable and toxic gas.

The ability of the TR to exclude smoke and gas relies heavily upon the integrity of its outer skin or fabric, the effectiveness of external door sealing and sealing of penetrations for cables, services etc. In addition, it is essential that the HVAC systems can be shut down, either immediately following an incident or, automatically on detection of smoke or gas at the inlets. HVAC shutdown will involve the closure of fire dampers at the inlet and exhaust ducts and fan shutdown.

The survival time of the TR depends upon the level of air leakage after shutdown. If the HVAC does not shut down effectively, ie fans do not stop and dampers do not close as required, the performance standard for survival time will not be met.

Companies often test TR HVAC shutdown as a series of discrete tasks, ie:

- initiating fan shutdown and damper closure from the control panel in the fan or control room;
- testing of the inlet smoke and gas detectors without initiating a system trip;
- checking inlet and exhaust damper position by observation of indicator lights on a panel or display screen.

Similar tests have been carried out by verifiers.

OSD inspectors, however, have required that ‘full loop testing’ be performed, ie the application of smoke or test-gas to the detectors at the HVAC inlets in order to initiate an automatic shutdown of the fans and closure of the inlet and exhaust dampers. In addition, the actual position of the inlet and exhaust dampers was required to be confirmed by direct visual observation. It appears that this form of testing has not been routinely carried out as part of Verification or of the maintenance management arrangements. HVAC system testing often appears to be carried out piecemeal in order to avoid shutdown and the question must be asked if such deficiencies also exist in the testing of other SCEs and Systems.

The results shown in Appendix A3.1.3 shows the distribution of traffic light colours scored for all 56 of the systems tested. With 64% of tests showing some form of failure there is a picture of inadequate testing and very poor reliability for TR HVAC shutdown systems.

The poor performance in this area was raised with industry at an early stage in the inspection programme through the IIWG. As a result, an HSE/Industry sub group was set up to address the issue and produce a good practice guide for maintenance and testing. This has been published in the form of an HSE Semi Permanent Circular (SPC)[11] and Information Note 2006/1[12].

One likely cause of the poor performance of HVAC systems is that many installations no longer employ full-time HVAC technicians and rely on their own mechanical discipline resources or intermittent visits from technicians shared with other platforms. As a result, understanding of the systems by offshore personnel has declined, levels of maintenance have decreased and test intervals have been increased. This is reduction in emphasis on TR HVAC maintenance (and as a result, TR integrity overall) is considered to be a major failing and an indication that industry has lost sight of the potential for major loss of life during major hazard incidents. OSD has actively engaged the industry on this matter and has provided new guidance to raise awareness and improve industry testing procedures.

Deluge

Deluge systems are often specified in safety cases as the key mitigation measure in the event of fire. Of the 20 Deluge system tested 10 had red or amber traffic lights assigned. This poor performance is a reflection of, in many cases, corrosion of carbon steel deluge pipework. Maintenance of many systems is a continuing struggle against corrosion which blocks pipework and nozzles. The primary reason for continuing problems has been a general reluctance to replace corroded deluge systems with low corrosion materials due to the costs involved. Corrosion removal and inhibition techniques are now available but they require a level of monitoring and maintenance themselves.

However, many systems were designed and installed under the requirements SI 611 for general area deluge. Since then there has been a significant improvement in the understanding of the effects of deluge on oil fires, gas jet fires and explosions. Dutyholders in many cases are attempting to maintain their existing deluge systems without having had a design reappraisal in light of current knowledge. Corroded carbon steel deluge systems have been replaced with like for like material over gas treatment plant or, general area deluge has been maintained where plant has been decommissioned or removed. A reappraisal in such areas could potentially allow the removal of the deluge with a corresponding reduction in the maintenance burden.

In light of current knowledge of major hazard mitigation and the level of design life extension being seen across the UKCS a new approach is required to deluge system performance and maintenance basis. These issues are covered in depth in new guidance on fire and explosion hazards associated with ageing offshore oil and gas platforms[9]. Maintenance management of deluge systems should be developed in light of this guidance.

Fire pumps

Fire pumps performed generally well with 76% of tests proving successful and 7% of tests giving major failures, ie 2 out of 30 tests. This reflects a general practice across the industry of frequent testing although any failures should be regarded as of concern. The failures found in KP3 generally related to changeover between main and back up pumps where pressure trips or changeover valves failed. The maintenance and testing of these ancillary systems and equipment appears to be an area of weakness. As with the testing of HVAC systems this reflects an inadequacy in testing and verification activities offshore, where systems are tested on a piecemeal basis (mainly for production convenience). Whenever possible, systems should be subject to full loop tests to ensure that all parts of the instrumentation and control are operating as required.

ESDV tests

Results were generally very good with no red traffic lights assigned and 63% green although the number of tests carried out was relatively few.

3.2 Overview of performance according to installation type

Sorting the traffic light matrix by installation type illustrates some differences in performance.

Mobiles perform markedly better than all other types of installation over Management System template elements other than for Maintenance of SCEs (the overall worst performer).

Performance of fixed installations was in a middle category.

Floating production installations (FPs) include semi-submersible rigs converted for production and FPSOs. They performed poorly compared to mobile rigs and fixed installations.

3.2.1 Mobiles (Appendix A3.3.1)

The 10 mobile installations performed better in all template elements other than for maintenance of SCEs and maintenance basics. For these elements the issues were related to:

- lack of a formal maintenance strategy;
- poor implementation of maintenance change requests;
- weak links between performance standards (PS) and work orders (WO);
- differences in function testing requirements between the WOs and PS;
- generic performance standards which were not measurable.

Mobiles also performed better than other installation types in relation to physical state of plant with only one red traffic light related to cranes.

Two deluge tests failures recorded related to lack of a performance standard for fire pump and blocked and miss-aligned nozzles. The HVAC red traffic light related to failure of damper closure. Both of these failures are common to other installation types.

The stronger overall performance of mobiles can be attributed to the fact that they operate under a different regime to FP and fixed installations, namely:

- a less complex and smaller overall installation size;
- no major oil and gas processing systems and so in practice present a less complex maintenance task;
- fixed installations have a design life, with no market value at end of life. Mobiles have a market value for resale and so encourage good upkeep of rig equipment;
- a rig is not continuously drilling, whilst a platform is continuously producing (apart from shutdowns). This gives opportunity window (eg during rig move, or

when engaged in coiled tubing or well intervention work) to do maintenance work on equipment not in use at that time;
- client companies will audit mobiles extensively before and during hire periods;
- there is a strong commercial incentive to keep rig downtime to a minimum. Contracts will be negotiated on this basis;
- all mobiles will have a close relationship with their classification authority. Rigs will require regular inspection of structure and equipment (seawater systems, fire fighting, power generation etc) by classification society surveyor to keep the rig 'classed';
- Mobiles have smaller, leaner management teams and usually a more direct and closer relationship with senior management than is the case with production installations;
- often the dutyholder employs most of the key crew on a mobile. On a fixed installation there may typically be very few direct employees of the dutyholder.

Many of the above factors are not applicable to fixed and FP installations. However, several factors could be transferred with significant benefits to integrity performance, ie:

- close, detailed management oversight;
- greater interaction with senior management, a more intimate knowledge of the assets they manage and the risks they are subject to;
- extensive, frequent integrity-related audits.

The weakest area of performance related to maintenance of SCEs is common to both FP and fixed installations and are discussed in Section 3.3 below.

3.2.2 Floating production installations (Appendix A3.3.2)

The number of FPs inspected (8) was approximately 9% of the overall number of inspections carried out and this small sample size should be born in mind when interpreting performance. There did not appear to be a significant difference in performance between FPSOs and floating production platforms (ie semi-submersibles converted for production). FPs performed well in:

- maintenance basics;
- communications onshore/offshore;
- reporting to senior management;
- key indicators of effectiveness.

The five poorest performing areas overall (Section 3.2. above) were reflected in FPs performance but with a significantly higher proportion of red traffic lights assigned than for fixed installations and mobiles. In addition both Maintenance System Evaluation and Measuring Quality of Maintenance work performed poorly with a significant of amber lights assigned. This is in contrast to mobiles and fixed installations where performance in these areas was relatively good.

Reasons for this relatively poor overall performance may relate to the different nature of their operation compared to mobiles and mixed installations. FPs have generally similar levels of process equipment to fixed installations. However, their operation can differ in many ways and can be more complex, Moreover weather conditions have a much greater effect on their operations. They also have features related to marine operation which contribute to maintenance management problems. For example, some FPSOs rely on thrusters to maintain their orientation, which must be replaced from time to time requiring additional personnel and bed space. Accommodation provision is often lower on FPSOs than on many fixed installations and increasing it for such work may be impractical. While it may be possible to do the work in-situ, the additional manpower required for the task will affect bed space and hence impact on maintenance. They are also much more prone to the effect of weather on their operations and provision of flotel accommodation is impractical.

Issues related to the elements showing poor performance are discussed in Section 3.3 below.

3.2.3 Fixed installations (A3.3.3. Fixed installations)

Inspection of fixed installations dominates the overall matrix with areas of poorest performance common to Mobiles and FPs (although FPs performed poorly across more areas of the matrix). They are, in order of ranking;

i) maintenance of SCEs;
ii) backlog;
iii) deferrals;
iv) review of ICP Recommendations/Verification;
v) corrective maintenance.

The poor performance of Review of ICP Recommendations/Verification was exclusive to fixed installations. Issues here related to the ICP being seen as an internal inspection tool rather than independent assurance resource, deferral of ICP related work orders, poor follow-up of actions and lack of review of ICP findings.

The two worst performing elements in terms of red traffic lights also had a high number of amber lights assigned.

Key indicators for Maintenance Effectiveness, Reporting to Senior Management, Communication and Supervision were the best performing areas which are common to all installation types.

A detailed discussion on the areas of poor performance is contained in Section 3.3 below.

3.3 Specific template element issues (Appendix A3.4)

This section is based on the HSL analysis of inspection reports[5]. The template elements discussed below are the most poorly performing in relation to assignation of red and amber traffic lights throughout the inspection programme. They are common to both fixed and floating production installations, and to a lesser extent mobiles. The issues are those occurring most frequently across the inspection reports.

3.3.1 Maintenance of SCEs and measuring compliance with performance standards

As discussed earlier in the report SCEs underpin major hazard control. It is imperative that the systems for managing SCEs are robust and show high levels of achievement of performance standards.

The template element maintenance of SCEs consistently ranked with the highest number of reds and ambers. This element related to:

- reference to the relevant SCE performance standard in the work order;
- a description of tests to be conducted prior to post-maintenance commissioning;
- a demonstration that the relevant performance standards has been met;

- recording of test results (eg pass/fail/remedied);
- what should be done if the test does not meet the acceptance criteria.

The issues involved were common to measuring compliance with performance standards.

Common problems related to a lack of any link in the work order to performance standards and no formal requirement for testing or, high level, generic test requirements. Acceptance criteria that would enable the maintenance technician to know whether the performance standard has been met were often absent. As a result onshore management have been unable to monitor that their SCEs actually met their performance standards.

In a number of inspections it was found that performance standards were generic in nature without being specific and measurable. Examples of measurable criteria are valve maximum closure times and maximum allowable leak rates. An example of not being specific was where a dutyholder used the same performance standard across all their installations and there were differences in the actual systems on the installation that required changes to functionality. In these cases and others, this information was poorly used in planned maintenance routines to assure the duty holder that the SCE functioned as required. Thus the maintenance system did not clearly advise those concerned as to the functionality status of the SCE.

There is evidence that the offshore workforce do not understand link between the safety case, MAH analysis, identification of SCEs and development of their performance standards. The workforce is the last and critical line of defence against the occurrence of many incidents. Their full understanding of the role of the equipment they work with in providing barriers against MAH is therefore essential.

Good practices found in relation to maintenance of SCEs are;

- ensuring a clear link to the performance standard on the work order. This can be made either by a reference to the PS number or, if on the MMS itself, an electronic link to the performance standard. The easier it is to access the relevant performance standard the more likely the maintenance technician and supervisor are to reference it and understand its intended functional requirements;
- ensuring that the post-function system tests relate to the performance standard requirements and are clear and equipment specific (rather than generic). Clear pass/fail acceptance criteria with clarity on what to do if these are not met;
- the offshore workforce in particular, including management, being provided with training in what functions SCEs have in preventing, controlling or mitigating MAH. This relates to hazard control elements rather than QRA aspects and makes clear the purpose of testing.

3.3.2 Backlog

A simple analysis of the traffic light matrix shows that the backlog element of the inspections was consistently one of the weakest areas of performance. High levels of both safety- and non-safety-critical backlog and poor backlog management have been found across the industry.

The definition of ‘backlog’ has been found to vary across the industry, within companies and between onshore and offshore. Typically, it may be defined as, among other things:

- any work past the due by date generated by the MMS or;
- any work not completed within say one month of the due date or;

- any work not completed within a defined period after say, one month of the due date. Here the defined period can depend upon the maintenance interval or the criticality of the equipment.

For this reason the assessment of industry performance in relation to Backlog can be difficult. There appear to be no specific reasons why backlog should be defined differently across the industry. It can result in confusion and, in light of this, some dutyholders have simplified their definitions to try to provide a more understandable measure. This is an issue which may be contributing to the apparent lack of understanding of maintenance issues by industry senior management.

Maintenance intervals are initially based on the calculated reliability of the equipment often derived from manufacturer's data, which can be conservative. It is possible to over maintain equipment and the resulting burden placed on the maintenance management system and resources can be high. Maintenance intervals can be modified (ie extended) if justified by historical data. If maintenance intervals are extended without justification the potential for breakdown, or failure on demand, can potentially increase. At some point beyond the designated maintenance point, reliability will be expected to be lower, indicating reduced integrity. This has been clearly demonstrated in KP3 in the case of TR HVAC maintenance and testing. The level of maintenance has been decreased, resulting in longer test intervals, lower reliability and increased failures.

If maintenance is not carried out at or near the designated interval it will normally either be placed on a 'backlog' work order list or will go through a deferral process which is discussed below. If equipment is in backlog, it does not necessarily mean that it is not working, or will not be available when required. However, the amount of equipment in backlog can be viewed as an indication of potentially reliability and availability of the plant and equipment.

For SCEs and systems the level of backlog reflects their effectiveness as barriers against major accident hazards events. Assuming the maintenance dates have been set appropriately, low backlog is an indicator of high reliability and ultimately, integrity. HSE's position is that while some non-safety-critical maintenance backlog may be acceptable, the target for SCE backlog should be zero hours. It is acknowledged that this may not always be fully achievable but a 'zero' target should be the aim.

KP3 focused on safety-critical maintenance including backlog, both planned and corrective (breakdown and repair). Safety-critical planned maintenance is often subdivided into several categories based on perceived criticality. Non-safety-critical maintenance will be recorded as a separate category and generally managed with a lower priority. The interaction of non-safety-critical with safety-critical systems is an area which is not well understood. High, non-safety-critical backlog could potentially have an impact on safety-critical systems. While management of non-safety-critical backlog is not directly within the scope of KP3, the high levels found across the industry are of concern to HSE.

High levels of SCE backlog and its poor management have been found to have the following common themes:

- lack of sufficient technical resources to complete the maintenance;
- lack of bed space to accommodate sufficient resources;
- large amounts of spurious data within MMS preventing a clear picture of backlog to be obtained;
- large amounts of spurious data within MMS preventing prioritisation of critical maintenance tasks;
- lack of planning resources onshore and offshore resulting in overload of offshore management and supervision;

- separation of maintenance planning from overall project and resource planning.

The examples given below should be considered as good practice which are evident on installations where maintenance backlog is low:

i) Key performance Indicators (KPIs) supported by high quality data are a powerful tool for giving a focus to backlog reduction.

ii) The use of a target for backlog levels which is moveable (downwards) will assist in providing achievable goals for improvement in backlog management.

iii) Setting of Trigger Points for backlog levels, which when hit, initiate management actions such as;

- providing additional resources; or
- some form of campaign maintenance; or
- examining current project related workloads which are impinging on planned safety-critical maintenance; or
- assessing the effects projects may have in terms of taking up bed space, drawing resources away from maintenance, giving an additional load to maintenance teams in equipment refurbishment and repairs.

iv) Provision of dedicated planning resources both onshore and offshore which interact closely with all areas of the operation. The planners should be tasked with integrating maintenance planning with operational issues, equipment shutdowns (eg rotating equipment refurbishment) and provision of all associated resources (eg scaffolders, riggers, high line work etc.) In this way pinch points in the planning in relation to resources, equipment and beds space can be planned out.

v) a MMS which has been cleansed of spurious maintenance data, allowing a clear prioritisation of maintenance tasks,

3.3.3 Deferrals

Deferral of maintenance and testing is needed when management system has not provided resources for the task. The deferral process is recognition that there is potential for degradation of the SCE. It should provide the means to compensate for the degradation and the potential increase in risk. The deferral process is an additional demand on resources and an unnecessary cost to the company. Therefore management should aim to eliminate the factors that give rise to deferrals.

Deferred maintenance is an area where performance was found to be consistently weak. Issues concerned unclear processes and procedures for deciding whether and when to defer maintenance. This situation is exacerbated where backlog definition is complicated and not well understood.

Adequate deferral procedures existed in some cases but were not being followed, procedures were not understood, could not be explained by TAs or management and an absence of audit failed to identify deficiencies. Deferral records were found to be inadequate with some deferred equipment having been 'lost' in the MMS records for some considerable time.

Due to weak deferral procedures decisions to defer maintenance were often based on poor assessment with inadequate involvement of management and TAs, poor assessment risk and mitigation measures where appropriate and infrequent inspection of deferred equipment. In several inspections crews had been operating with draft procedures which had never been finalised or fully approved.

Lack of available resources and bed space, together with pressure to continue production, were cited as reasons for deferral. In one case it appeared that deferral was being used to reduce backlog figures with no clear justification for implementation of the procedure.

Where deferral appeared to be operating appropriately, procedures were clear with strong involvement of TAs and management both onshore and offshore. The risk assessment process was strong and implemented fully. ICPs were informed and inspection frequencies for the equipment were increased. Oversight by management was essential with auditing of deferred equipment records and approvals in place.

3.3.4 Corrective maintenance

Corrective maintenance is frequently reported in relation to 'corrective backlog', ie breakdown and repair work that cannot be completed within a specified time period. The definition of corrective backlog may again be complicated by complex backlog definitions. Reporting only corrective backlog will give a distorted picture of plant reliability as it will not include information on day-to-day breakdown and repair activities and the consequent level of resource required to keep the plant operating. The reporting of this day-to-day work can be affected by poor recording of work activities by maintenance personnel offshore.

High levels of breakdown and insufficient resources were frequently cited as issues which impacted heavily on planned maintenance. A lack of a strong planning resource led to 'fire fighting' situations with subsequent stress for supervisors and technicians.

An absence of formal procedures laying down requirements for consultation with TAs, implementation of risk assessment and mitigation measures/additional barriers and management approval was an additional issue.

3.4 Supplementary factors affecting performance

3.4.1 Company performance and communication (Appendix A3.5)

OSD carried out inspections in teams of three or four assigning traffic lights by team consensus. In addition, peer review external to the team was applied by HSE to each report, to ensure objectivity in reporting.

Sorting the matrix in relation to the number of red and amber traffic lights assigned gives a broad indication of installation performance. However, while poor performers and good performers are clear, there is insufficient precision to discriminate between adjacent installations in the ranking. The reason being that while the assignation of red traffic lights is clear (a major failing of system hardware or management or partial failure with a history of failure), amber traffic lights could range from a little poorer than green (tested or inspected but with no significant issues found) to just better then red. This spread in the significance of amber traffic lights means that the location of an installation on the matrix should be taken as a broad indication of good, mid-range or poor performance.

Variation in maintenance management performance between companies and within individual companies is wide. This applies to all company types, from multi-nationals, to lean companies with only one or two installations, to drilling companies. However, the evidence is less clear for drilling companies as only single installations were inspected in the majority of cases.

The reasons for the variations are acknowledged to be complex depending upon a wide range of factors including design, original equipment specification, age, process complexity and size. Analysis shows that there is no simple relationship between variation in maintenance performance between assets and any of these factors. Original equipment specification can be a factor in relation to reliability and obsolescence with variations in performance between platforms of similar age. Age can be a factor where the installations have been allowed to degrade significantly, but some older installations have performed well.

Where installations are performing well the good practices involved, which are not dependent on installation design, are not, in many cases, being shared. This has been found not only with respect to the sharing of good practice and solutions between companies but also within individual companies.

Large companies may have 'asset groups' operating in different parts of the UKCS with their own management teams and systems. While operating under an overall management umbrella, they often work in relative isolation in relation to systems of work, procedures and resourcing. Asset or field mangers often have autonomy and the authority to give their interpretation of federal standards and systems. This is accepted to be appropriate and healthy in that it can encourage innovation and improvement. However, without an overarching system of audit and review, poor practices can persist and, importantly, good practices will not be shared across the organisation. For example, inspectors found different asset groups within large companies had different definitions of backlog and definitions of safety-critical equipment. These have had a significant effect, between platforms, on the levels of safety-critical maintenance work orders generated and subsequent levels of backlog.

A further complication relates to the level of asset disposal over recent years. KP3 inevitably provides a snapshot of performance. As a result, where an acquisitive company has taken over a range of ageing assets from different operators, the variation in performance may in part be due to differences in performance of the original operator. Rationalisation of maintenance management systems, practices and performance across asset groups can take some time to effect.

3.4.2 Change management

Sharing of good practice within companies has been observed during the programme resulting in a corresponding improvement in performance across assets. However, sustained improvement can be very susceptible to changes in organisational structure and personnel movement.

For example, a dutyholder took onboard recommendations arising from a first KP3 inspection and transferred these across its installations. These related to:

- clarification of backlog definition and understanding between onshore and offshore;
- rationalisation of data in the MMS to give a true picture of SCE backlog and allow prioritisation of maintenance tasks;
- clarification and strengthening of the risk assessment process for correctives and deferrals; and
- clarification of lines of responsibilities on and offshore for decision making with respect to risk assessment and identification of mitigation measures.

A second KP3 inspection on another of their installations showed a marked improvement. Procedures had been improved, responsibilities clarified and the maintenance system database had been cleansed and rationalised. As a result backlog was being managed downwards and effectiveness of their MMS had improved. The lessons learned had been implemented across their other platforms with corresponding improvement, demonstrating good communication, transfer of knowledge and learning.

However, following the second inspection the company went through a change in facilities support contractor which involved significant changes in the management structure. At the same time personnel changes occurred and there was an overall loss of knowledge and experience. As a result the performance in the third KP3 inspection dropped and the gains made earlier were lost. In particular, the field backlog appeared to be increasing and implementation of a new deferral management process had been affected. The reasons for the decline in performance were attributed to changes in management structure and personnel affecting the efficient implementation of systems and procedures. While management were aware of the issues and were addressing them, the progress made by the company had been put back by at least a year.

3.4.3 Impact of project work on maintenance

Project work for well or field development usually has a higher onshore management profile than routine maintenance work and as a result receives a higher priority. This priority is realised in the allocation of bedspace, specialist resources etc, therefore having a significant impact on maintenance of safety-critical elements. The situation can be greatly exacerbated if project overruns occur.

3.4.4 Verification

Independent verification bodies have valued KP3 and stated that it has strengthened their position by raising the profile of integrity management of SCEs. The industry has employed several verification bodies to carry out their own internal KP3 inspections using HSE's templates and traffic light system. Some dutyholders have shared this information with HSE, thus demonstrating a proactive approach and a readiness to rectify deficiencies.

An example of one of the stronger good practices in the verification area is the robust management of the ICP findings to close out within a short time period. For problems with hardware on the platform the platform personnel tried and in many cases succeeded to clear them before the ICP left so that he could witness the resolution of the problem. Those ICP findings that required onshore personnel input or for them to resolve were again actively managed with timescales and senior management involvement to clear quickly.

One further area of concern to HSE has been the continued and extensive poor performance of TR HVAC System testing. This has raised doubts about the way the verification system is specified and the depth and quality of testing.

4 Possible underlying issues and consideration for improvement

This chapter outlines possible underlying issues and common failures and identifies lessons the industry should be learning, or is already in the process of tackling.

Leadership

Leadership is a key function in improving understanding, simplification, challenge and learning in major hazard control and ultimately in performance. During the programme a number of issues have been identified which are capable of being addressed by improved leadership at senior level. The complexity of many maintenance systems and the quality of maintenance data is hindering the ability of management to gain a clear understanding of the state of the plant and equipment. This report indicates that the number of red and amber traffic lights assigned to installations during the each year of the programme did not show any downward trend, ie there was no significant overall learning in maintenance management systems during the project (section 3.1.1).

The physical condition of installations (section 3.3.3) has been of concern throughout the programme. Although UKOOA had driven the issue of integrity forward centrally. this has been largely at tactical/practitioner level through specific work groups. There had been no senior management driven central approach until the first quarter of 2007. Moreover, industry senior management appears to have been slow to give full support for and begin using the newly developed industry performance indicators.

There is no doubt that senior managers were aware of HSE's concerns on asset integrity and KP3 has shown that they were receiving performance data on issues such as backlogs. However, many managers have failed to improve standards by prioritising resources for maintenance work at the expense of other projects. The Industry Asset Integrity Leadership team has concluded that the industry needs to improve senior management understanding in this area.

HSE believes that there are clear safety and business risks associated with poor integrity. Consequently, the lack of progress in asset integrity must be as a result of senior management's level of understanding or appreciation of the major hazard risk control model described in section 2. The level of understanding must extend to the detail of their maintenance management systems and key performance indicators associated. Industry leaders have agreed that asset integrity is a priority and perhaps increased understanding of major hazard control will lead to more practical leadership. This issue is reflected in the Baker Report into the Texas City Refinery incident[7]. The impact on safety of long-term strategy and decision making by senior and executive mangers depends on their understanding and awareness of the risks posed by their operations (especially major hazard risks).

The industry Asset Integrity team has taken the step to try to develop better leading indicators for integrity. The industry should now take the bold step of setting an industry objective using a common definition of backlog and strive to ensure all maintenance is completed before the due date or report total hours outstanding.

Industry could also take the positive step of embracing the performance indicator that uses Verifier anomalies as a surrogate measure of major hazard safety. There is a wealth of information to be obtained by extending this approach to report and categorise all anomalies. Currently a rather limited approach has been taken.

Understanding the major hazard control loop

SCEs are the major barriers to the realisation of MAHs. SCEs are developed from the safety case by analysing the major hazard scenarios, identifying the important controls and developing performance standards. The evidence from the programme is that this is not well appreciated or understood at all levels in the company. The whole workforce from offshore technician to CEO needs to understand and commit to ensuring that this major hazard control loop is applied rigorously. Action is needed to address the lack of understanding and commitment at all levels.

The prominence of the engineering function

Data from hardware and system tests provide a very good indicator of the effectiveness of the whole maintenance systems. It can be used to aid maintenance planning and improve plant efficiency improving 'up time' as well as major hazard safety. All available evidence indicates that an efficient, productive and well managed business will also have high safety performance. This data is only of value if it is of good quality and there is the capability for good onshore analysis. The amount of data in maintenance management systems is extensive. The quality is often inconsistent, particularly in recording the 'as found' condition rather than the 'maintained' condition and in reporting the cause of failure. These weaknesses significantly undermine the primary objectives for improving company safety and production performance. It is perhaps significant that there was an increase in unplanned downtime for the industry as a whole during in the last year for which performance results were available.

The owner of this data is the engineering function. It is, therefore, probably not coincidental that in the last 10 years or so the prominence of the engineering function has declined both offshore (offshore maintenance manager) and onshore (chief engineer). Currently the technical authority function is under pressure often resorting to fire fighting rather than its strategic role to provide expertise and judgement on key operational engineering issues. The voice for the engineering function which can provide the backstop on asset integrity lacks the appropriate authority in many companies and the industry needs to reflect on how this can be addressed.

Skill shortage

Skills shortages in engineering disciplines is without doubt a worldwide problem affecting the whole spectrum of industries. However, the oil industry skills shortage is, in part, a problem of the industry's own making. As a result of low oil prices in the 1990s industry shed significant numbers of onshore and offshore workers with the resultant loss of skills and experience. Resourcing and staffing of the maintenance functions frequently was a target for cost reduction which has resulted in a lack of confidence that the industry is a reliable long-term career prospect for skilled workers. The situation has been exacerbated by the general reduction in skilled labour as the declining onshore heavy industries, which have provided ready sources of skilled labour in the past, are no longer available.

The industry has taken action over recent years and put various schemes in place to attract more people into the industry, eg graduate schemes, innovative web-based systems and the excellent modern apprenticeship scheme. HSE is concerned that these schemes may not meet industry demands and there is increasing anxiety in the offshore workforce about competence, skills and lack of experience.

There is some good practice of contracting companies taking on and training staff but the financial and contractual arrangement can make it difficult to provide offshore training. It is essential that the industry works cooperatively to provide the skills, training and competences required to enable the workforce to be capable of delivering the standards of integrity required in a high-hazard industry.

Investment

The low oil price in the 1990s impacted on investment in several ways. Cost Reduction In the New Era (CRINE) saw capital investment in design cut to a minimum to cope with the relative cost of lifting oil and the oil price. One result was that the size of topsides for installations was minimised and CAPEX reduced often at the expense of future OPEX. In addition, investment in maintenance and crews on existing plant was minimised based on reduced economic life expectancy of installations. However, the oil and gas high prices in the next decade has seen the economic life expectancy of many installations extended by between 10 and 25 years. The increase in activities has resulted in greater demand for skilled human resources and a shortage in availability of accommodation vessels to support maintenance and investment. The reduced provisions for accommodation on installations which was a feature of CRINE developments has further exacerbated the difficulties of delivering both increased levels of maintenance on aging installations and the necessary upgrades to maximise output. Those companies that had the foresight to take the longer-term view in the 90s and continued with maintenance and resisted short-term solutions are currently benefiting from those decisions.

Some companies looked at the economic life expectancy during this period and set a strategy to sell assets. In many cases this resulted in short-termism in maintenance planning impacting on overall condition of the plant in particular the fabric. This short-term approach also fails to recognise that some assets have a strategic use that may be of value to others in future tiebacks. This raises both safety and sustainability questions as to whether there is sufficient investment in maintenance of key installation to provide long-term sustainability.

Learning and communication

It is clear that there are some examples of good communication between individual assets but overall across the industry there is considerable room for improvement in information sharing and consistency of implementation of management systems between assets and between companies

Learning is achieved by identifying and sharing best practice, and by having process to enable the learning to be embedded,

Companies audit and review arrangements provide mechanisms to identify good and bad performance and share learning. Current work in OSD has confirmed that company audit arrangements in many cases are not being used effectively to learn about performance and share these learnings. Without the intelligence to understand how they are performing, companies cannot address poor performance and share good performance. The industry needs to consider how audit can be used more effectively.

It is unlikely that improved learning can be successful driven from an individual installation and needs to be company driven. Trade associations play an important role in facilitating learning but companies must provide the drive and the process to enable learning to be embedded. It is probably not coincidental that the industry has over the last decade dismantled many of the technical work groups that contributed to the initial learning on major hazard control. HSE’s phase 2 project on asset integrity is examining company's internal audit arrangements and their role and effectiveness in facilitating cross-organisational learning.

5 Good practice

Although the programme revealed that throughout the industry there was considerable room for improvement, there were examples of good practice found in many companies. To capture these and aid cross-industry learning, good practice observed during inspections was recorded and a list is provided on the HSE website at:
http://www.hse.gov.uk/offshore/goodpracticelist.pdf.

Several of the 'stronger' good practices that will assist in achieving effective maintenance management are described below.

Some of the good practices listed may be considered merely normal practice by many operators. However, standards are not uniform across the industry. What might be considered weaker examples of good practice have also been included as they are not universally applied. Information and good practice sharing, both between companies and within them, has been found to be poor.

The good practices observed tend to fall into specific categories. These are listed in Table 1 below along with the practices that lie within them.

Table 1: Good practices

CATEGORY	ISSUES	GOOD PRACTICE FOUND
MMS data quality	Many MMS have large amounts of spurious data as a result of 'daughter' work orders, work completed but not signed off, inadequate or inappropriate classification of safety- and non-safety-critical equipment.	Dedicated resources were provided to clean data in the MMS and ensure classification of SCEs/non-SCE as appropriate. Where MMS data has been cleansed backlog figures have been seen to reduce as a result of the removal of spurious work orders. Prioritisation of work, forward planning of resources maintenance tasks and managing backlog downwards becomes possible.
Supervision	The issue of supervision falls into three areas: ■ the regular presence of offshore management on the plant is very important; ■ regular visits by onshore senior management with an agenda to challenge major hazard control; ■ regular visits by TAs offshore.	Senior and executive management making regular visits to all of their assets, communicating company strategies and plans, listening to issues directly from the workforce, gaining an understanding of problems with SCEs, testing and verification leads to improved performance. Technical authorities visiting their installations on a regular basis. They get involved in the work going on on the plant, become known to the supervisors and technicians, improve communications, their knowledge of the plant and systems for which they are responsible and their effectiveness in solving problems and involvement in incident management.
Communication of status of SCEs/maintenance system data and reporting	Communication of maintenance system data to the offshore workforce. The greatest demotivator is to feel that you are working in a vacuum with no knowledge or understanding of how good or bad things are.	Provision of 'understandable' data on maintenance system and SCE status to the offshore workforce. This can include: ■ graphs showing backlog trends, levels of breakdowns and correctives etc and progress towards targets; ■ bar charts showing backlog, breakdowns etc by discipline area; ■ status of SCEs, ie impaired with current mitigation measures in place; ■ information giving reasons for poor performance.

CATEGORY	ISSUES	GOOD PRACTICE FOUND
Reporting	Reporting the status of the maintenance system effectiveness and SCE integrity.	Senior management ensure that the reports provided include the appropriate metrics to give a full picture of maintenance system status, eg data on not only corrective work in backlog, but the level of day to day breakdowns which impact on planned maintenance or data on pipework inspection programmes and corrosion management status. This improves understanding of the system performance. Regular audits of integrity management systems including SCE maintenance management will assist in ensuring that the reporting systems are effective.
Analysis of availability	Relatively few dutyholders measure availability and ensure that the systems are meeting their performance standards. The analysis of availabilities is important in that maintenance intervals are based on availability and reliability data for the equipment. Where maintenance backlog is high this is an indication that the overall reliability of SCEs may be lower than required.	Availabilities can be measured by a once yearly, monthly, weekly or daily on line analysis. In order to achieve an online analysis, rather than by reviewing long text on work orders, a fault code system is provided. Such analysis has been shown to be practicable and should be the aim of all SCE assurance strategies (see examples below). Measuring availabilities will not only assure the performance of these systems but it will assist in identifying specific components and equipment that are failing.
Risk assessment and mitigation measures	Lack or risk assessment and formal authority for continued operation when SCEs are found to be degraded	A formal, robust management procedure exists which outlines the risk assessment process, levels of authority and technical expertise required to be involved and review requirements. The risk assessment is based on the role that the SCE plays in providing a barrier against MAHs and provides a sound basis for the implementation of any mitigation measures or additional barriers required. A register of the assessments is maintained and audited on a regular basis. It is possible that individual operational risk assessments may be adequate but overall, the combined risks posed may be too high. It is essential that a process is in place to carry out periodic overall reviews. It is essential that an appropriate level of expertise is included in the process and that the responsibility does not always lie solely with offshore management. The part played by the failed SCE as a barrier to a major hazard incident, with reference to the major hazard analysis in the safety case, should be referenced if necessary.

CATEGORY	ISSUES	GOOD PRACTICE FOUND
Planning	The ability to plan is undermined by complexities in the levels of breakdowns, deferrals, project work requiring resources, bed space and manpower availability. Computerised maintenance management systems (MMS) can be slow to operate, have poor functionality, contain high levels of spurious data and be poorly understood by the maintenance personnel.	Where maintenance backlog is low or being driven down, a common characteristic is the existence of a strong planning function. This will include both onshore and offshore resources who not only extract maintenance schedules from the MMS but categorise and prioritise it. They develop ongoing plans (7 day, 14 day, 1 month, 3 month) which includes consideration of project work, drilling programmes, peripheral resource requirements (eg scaffolding, rope access), bed availability, manpower levels. These plans are then implemented by the offshore management and problems/pinch points can be properly managed. This also has the effect of improving the quality of reporting and overall installation management onshore. The offshore planning role is important in ensuring coordination with both operations, projects and maintenance management. The planning function is also essential in assisting in managing corrective work and reducing its impact on planned maintenance.
Inspection	As installations age, the level and rate of degradation of plant, structures and fabric increases rapidly. Inspection programmes can quickly fall behind and reducing the backlog in this respect will become difficult. In addition, the levels of data produced can be high and if not managed carefully to ensure continuity, onshore resources can be overwhelmed to the point where they cannot keep up.	The presence of inspection engineers back-to-back has been seen to contribute to effective corrosion and integrity management. Their knowledge of the plant and systems is seen to improve, assisting them in ensuring that their programmes are comprehensive and that line diagrams etc are up to date. Their permanent presence on the installation can help ensures that the management and analysis of the data produced in effective and that actions generated from it are carried out.
Definition of backlog	Backlog is defined in many different ways across the industry. Maintenance can be shifted into backlog based on, say, a fixed period after the due date or a 'window' after the fixed period. The window can be based on the maintenance interval or equipment criticality. Onshore and offshore personnel may have different understandings of the definition. The more complex definitions make decisions deferral decisions more complex and management of backlog more difficult.	The ability to manage backlog downwards has been seen to be accompanied by a decision to simplify its definition to 'any maintenance not completed within a fixed period of the due date. This period will be based on a combination of factors including equipment criticality and maintenance interval. The definition makes scheduling and overall planning simpler and assists in ranking by criticality. A simple definition of backlog will assist senior management in their understanding of maintenance management issues and clarify resource requirements.

CATEGORY	ISSUES	GOOD PRACTICE FOUND
Competence	Competence encompasses not only technical qualifications but the knowledge and ability to work within company procedures effectively. Many operators have extensive and adequate maintenance management procedures for deferral management, risk assessment on SCE breakdown or impairment, implementation of risk reduction and mitigation measures. Knowledge of the procedures and their implementation can be weak, especially offshore.	Offshore personnel have been given training in the part SCEs play in providing barriers to MAH (see Communication and Risk assessment/mitigation measures above). The result is that they are much more likely to appreciate the reasons behind procedures. They were more aware of the importance of ensuring MMAS data quality, consideration of risk reduction and mitigation in the event of SCE failure.
ICP involvement	ICPs play a critical role in assuring the performance of SCEs. However, their involvement in aspects of maintenance management including deferrals, consideration of risk reduction and mitigation measures and provision of additional barriers against MAH in the event of SCE failure or degradation is often limited.	While IVBs were not always directly involved in decision-making processes, they did provide a very useful contribution based on their knowledge of the performance standards and potential interactions between systems. It is essential that they remain fully appraised of failure or degradation of the SCEs and systems in order to ensure the integrity of the verification scheme and arrangements. Their involvement ensured that the status of verification anomalies is properly monitored and recorded.
Supervision – use of lead technicians	The inability to verify the quality of completed maintenance work in areas outside discipline of the supervisior/lead tecnician. They have to rely on the competence of the technicians to self check and must use post maintenance breakdowns as an indirect measure of quality of work. They cannot properly fulfil the roles of maintenance management/planning and supervision adequately.	Lead technicians have been used as a valuable resource in that they will be competent to verify maintenance work in their discipline areas and can play a role in day-to-day supervision of their teams. They have allowed maintenance supervisors to fulfil their role in maintenance planning and can assist the decision-making processes following equipment breakdown. They have provided an effective conduit for communication with onshore TAs and can provide a valuable resource in the event of absence or sickness of supervisors.

5.1 Specific good practice examples

Example 1

This example relates to the analysis of maintenance data and its presentation in such a way that it is understandable by all levels of the workforce from non-technical offshore personnel to executives. The information provides a clear picture of the health of safety-critical equipment onboard and the performance and status of maintenance management.

Safety Critical Element Impairment Risk Assessments (SCEIRA):

These are conducted when operations, inspection, test and maintenance and/or independent verification activities reveal asset condition that potentially affect safety-critical element performance and therefore an asset's ability to respond to major accident scenarios described in asset safety cases.

Conducting a SCEIRA involves multi-disciplined teams in:

- assessing SCE impairment risks;
- identifying pre (as found) and post mitigation risk levels;
- specifying the actions required to restore SCE integrity to an acceptable standard.

Completed SCEIRA are subject to technical authority and management review at a level dependent on the level of risk presented by the impairment.

All SCEIRAs are registered and subject to periodic review based on risk. Status is reported weekly to asset managers. The SCEIRAs are referenced on SCE risks status posters issued monthly for display on the offshore asset.

Example 2

This example relates to a global analysis of the health of diverse systems in relation to the integrity of hydrocarbon containment. Its strength is that it is capable of identifying interactions, deficiencies and gaps where cumulative risks can arise, and providing the opportunity to properly address them.

Gap analysis process

A gap analysis tool has been developed called OGRE (Oil and Gas Release Elimination). This assesses the health of all the essential elements of hydrocarbon containment programme. OGRE involves small, cross-functional operations teams systematically assessing the health of programmes and procedures key to hydrocarbon containment. These include programmes and procedures categorised as inspection, test, maintenance, operations intervention, management of change.

The OGRE process identifies gaps in key programmes not easily revealed by audit. OGRE relates all containment plant and equipment to their programmes and procedures, identifies gaps, assesses risks and establishes risk reduction actions, which are assigned to responsible individuals and are tracked to closure.

Example 3

This example relates to the communication of key information which will raise and maintain the awareness of SCE status to all levels of the workforce.

Communicating key asset and operating integrity (A&OI) risks

A&OI risks are depicted using the corporate risk matrix. A&OI risk is communicated via A&OI posters depicting OGRE risks and SCE condition risks, together with descriptions of risk reduction measures and their status.

The benefits of these systems include:

- systematic methods of revealing SCE related risks;
- communication of risk to all levels of the operations organisation;
- heightened awareness of SCE issues with operations management, technical groups, OIMs, supervision and workforce.

Example 4

Operational and maintenance metrics – measuring efficiency and effectiveness

The operational and maintenance metrics were used which targeted measures of leading and lagging parameters to aid improvement in safety and operational efficiency/effectiveness. These metrics are split in to two sections, the prioritisation metrics and the general asset status metrics and are displayed on a single sheet. The metrics are compiled monthly and displayed on a company web page for all employees to view and challenge.

Prioritisation metrics

Key systems on the installation are split into columns, each column is then constructed from a variety of parameters, including equipment availability, PMR backlog, number of corrective maintenance activities completed, cost to maintain etc.

The status of each of these parameters for each of the systems being monitored is assessed and a simple traffic light system is used to indicate one of three possible outcomes:

Red — The **trend** of the parameter being assessed is opposite to that desired (for example the number of backlog work orders has increased), and the desired target has not been met.

Green — The **trend** of the parameter being assessed meets that desired (for example the number of backlog work orders has decreased), and the desired target has been met.

Orange — The **trend** of the parameter being assessed meets that desired (for example the number of backlog work orders has decreased), however the desired target has not been met

The numbers of red, orange and green traffic lights are then used, in combination with the pre-determined criticality of the system and a pre-defined rule-set, to ascertain a prioritisation. The system with the highest score is reviewed to establish why it has that score and appropriate remedial actions implemented.

Note: A red is not an indication of a bad performance. It is a vehicle for promoting review and discussion.

General status metrics

In addition to the prioritisation metrics, a collection of 'general status' parameters are compiled. These metrics provide an overview of the status of work order control on the plant, taking into account all PMR and corrective work scopes and the rules defined in the work order control procedures employed.

As a whole, the general status metrics, combined with the prioritisation metrics provide the reviewer with a snapshot of the performance of the installation and key equipment in terms of operating and maintenance effectiveness and efficiency on a single page.

Example 5

Planning

A strong onshore and offshore planning process that includes all relevant aspects of offshore operations (project work, drilling programmes, peripheral resource requirements, bed availability, manpower levels) is critical in providing effective and coherent maintenance management. The example below describes how it fits into the overall SCE assurance process.

The company safety-critical element management relies on a number of key inter-related elements:

1. System custodianship

Every SCE has a designated system custodian who is responsible for ensuring that the SCE remains fit for service by ensuring that its performance standard is met, that maintenance and inspections are up-to date and issues are managed and risks properly mitigated until resolved. System custodianship is not necessarily the technical authority; to avoid overloading or bottlenecks the role is deliberately shared more widely within each functional team.

2. Maintenance management system

SAP is used to detail, schedule, execute and record all maintenance activities. All safety-critical maintenance tasks are cross-referenced to the relevant performance standard and are given a Category 1 priority code. The due dates for all major workscopes are recorded within SAP and these are used for planning, scheduling and backlog management.

3. Planning process

An 18-month plan is used to identify major workscopes and outages. A 90-day look-ahead plan is used for maintenance, inspection and projects work planning. Both of these are developed by the onshore planner. A 14-day detailed workplan is then developed by the offshore planner, from which the weekly and daily workplans are developed, reacting to ongoing local issues (manning, over-runs, unforeseen delays etc) as necessary.

4. Deferral and rescheduling process

A deferral and rescheduling procedure is used to authorise and track changes to the SAP scheduled dates for maintenance activities. The intention is to defer work as early as possible, ideally in the 90-day plan if tasks need to be aligned to outages, vendor availability etc. The system custodian must approve any deferral of CAT 1 (ie SCE) maintenance and identify any mitigation to ensure that the ongoing safety and integrity of the plant is assured. Deferred tasks do not appear in backlog as these are considered to have been executed and controlled through a risk assessed process. The bow-wave of work created by deferrals is, however, tracked and reported.

5. Backlog management

System custodians are responsible for reviewing any safety-critical tasks which are in backlog and confirming the new due date for completion. Any interim mitigation to allow ongoing safe operation until the task is completed is also identified and recorded.

6. Downgraded situations

Any SCE which cannot meet its performance standard or which has an unresolved issue which materially affects its performance is tracked via the downgraded situations register. This requires the impairment to be risk assessed in order to demonstrate the case to operate. Where mitigation is required in order to demonstrate the case to operate then these are recorded and their implementation and effectiveness tracked via formal regular review. Downgraded situations are also subject to regular review, and are signed off by, the asset leadership team.

7. System Custodian Reporting

Each system custodian produces an annual report detailing the performance of their SCE against the WSV. The report, which includes a complete review of the entire maintenance history for the preceding 12 months, identifies any issues or failures of the systems and reviews the accuracy and appropriateness of the current WSV. They all end with a statement of fitness for purpose of the system. Reports are distributed internally as well as to the ICP.

8. Interface with ICP

The ICP visits the engineering office once a month. One-to-one meetings with system custodians are arranged for those systems with observations or anomalies against them.

6 References

1 *KP1 Loss Containment Manual*
http://www.hse.gov.uk/offshore/lossofcontainmen.pdf

2 Offshore Hydrocarbon Release Statistics 1992 to 2002
http://www.hse.gov.uk/offshore/statistics/hsr2002/index.htm

3 *Key Programme 3 Asset Integrity Handbook*, May 2007,
http://www.hse.gov.uk/offshore/kp3handbook.pdf

4 HSE offshore oil and gas website: http://www.hse.gov.uk/offshore/

5 HSL interim report on KP3: http://www.hse.gov.uk/research/rrhtm/index.htm (yet to be published)

6 UKOOA Integrity Toolkit,
http://www.ukooa.co.uk/issues/health/docs/hydrocarbontoolkit.pdf

7 The Report of the BP US Refineries Independent Safety Review Panel (The Baker Report) http://www.safetyreviewpanel.com/cmtfiles/charter_related/Panel%20Report%20-%20January%202007.pdf

8 *Offshore External Corrosion Guide* HSE 2007
http://www.hse.gov.uk/offshore/corrosion.pdf

9 *Guidance on fire and explosion hazards associated with ageing offshore oil and gas platforms*, PS/06/24, T Roberts et al. 2007

10 The Public enquiry into the Piper Alpha disaster, Rt Hon Lord Cullen, HMSO, Nov 1990

11 Testing Regime for Offshore TR-HVAC Fire Dampers & TR Pressurisation Requirements, SPC/Enforcement/122

12 Testing Regime for Offshore TR-HVAC Fire Dampers & TR Pressurisation Requirements Offshore Information Sheet No. 1/2006 (Revised and reissued January 2007) HSE 2007 http://www.hse.gov.uk/offshore/trhvac.pdf

13 PILOT Website Vision for 2010, http://www.pilottaskforce.co.uk/data/pvision.cfm

14 *A guide to the Offshore Installations (Safety Case) Regulations 2005* L30 Third edition HSE Books 2006 ISBN 978 0 7176 6184 8

Appendix 1

Aims and objectives

The aim of KP3 is to ensure that dutyholders effectively manage the risk of any failure of structure, plant, equipment or systems, which could either cause or contribute to, or prevent or limit the effect of, a major accident and/or cause fatalities, ie the maintenance management of SCEs.

This is linked to the ten-year strategy of the UK offshore industry and Government co-operation, as expressed through the PILOT Vision[13]; that by 2010 the North Sea (and the UKCS in particular) will be the safest place to work in the worldwide oil and gas industry. KP3 was intended to make a major contribution to achieving this outcome.

The KP3 Handbook[3] defines the objective of the programme, to:

'Ensure that dutyholders effectively manage the risk of any failure of structure, plant, equipment or systems, which could either cause or contribute to, or prevent or limit the effect of, a major accident and/or cause fatalities'.

The KP3 objective is to contribute to the process of 'creating an environment in which dutyholders manage the integrity of plant and structure to ensure risks are as low as reasonably practicable (ALARP)'.

A1.1 Programme drivers

Evidence from inspection and investigation had shown that, while not applying to all companies or all installations:

- there were weaknesses in the implementation of statutory provisions for independent verification designed to assure dutyholders that their arrangements for securing the integrity of safety-critical elements are adequate;
- cost control, reduced offshore manning, and multitasking could - if poorly managed - have adverse effects on health and safety performance;
- some backlogs of maintenance was too high;
- a number of significant incidents had been due to maintenance or integrity failures;
- in addition there was a need to maintain the level of improvement in reducing the numbers of major and significant hydrocarbon leaks and reverse the rising trend in minor releases.

A1.2 Alignment with industry organisations and initiatives

Step Change in Safety is industry initiative intended to deliver the PILOT Vision mentioned above, to improve safety performance, awareness and behaviours throughout the UK oil and gas industry. It has focused its strategy on three critical areas shown as their 'Temple Model' (Figure A1). The 'third pillar' in the Step Change Temple model is asset integrity which underlines the alignment of KP3 with industry objectives.

Other stakeholders who have been involved with KP3 include:

- International Association of Drilling Contractors (IADC)
- British Rig Owners Association (BROA)
- Offshore Contractors Association (OCA)
- Independent Verification Bodies (IVBs)

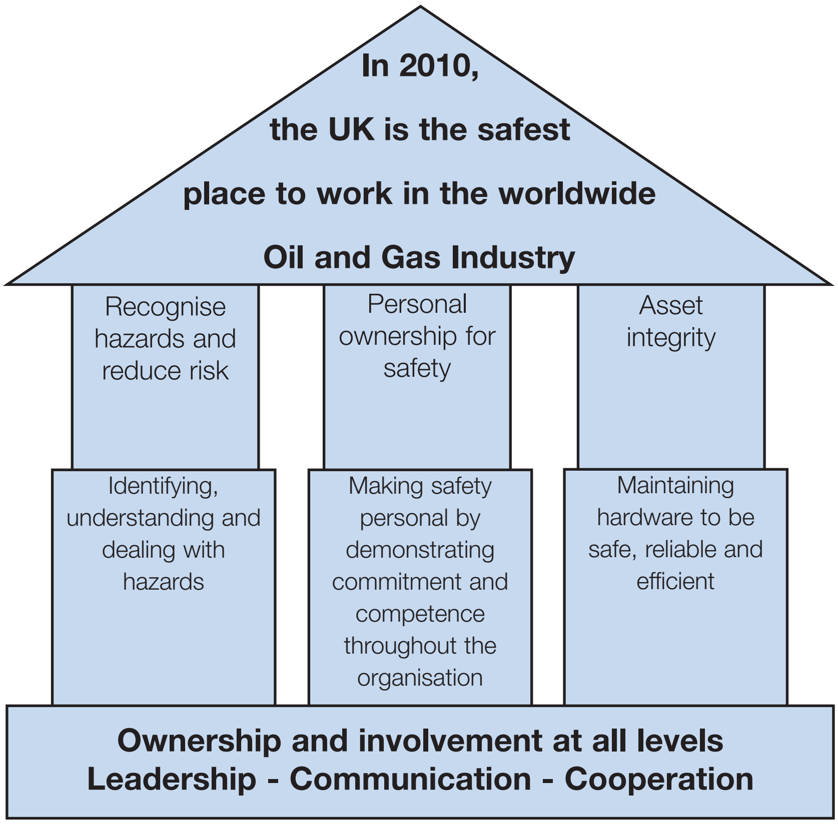


Figure A1 Step Change Temple Model

Appendix 2

Inspection programme

A2.1 Scope

The management of asset integrity is a very wide-ranging subject which covers virtually all aspects offshore operations. From a Health and Safety Executive perspective, asset integrity relates to any aspect of offshore operations which provides a barrier against the occurrence of major accident hazards (MAHs)[14] or assists in preventing death or injury to personnel. The IIWG agreed a definition of integrity as follows, which aligns with KP3;

'Asset integrity' is the ability of the asset to perform its required function effectively and efficiently whilst safeguarding life and the environment.

'Asset integrity management' is the means of ensuring that the people, systems, processes and resources which deliver the integrity, are in place, in use and fit for purpose over the whole lifecycle of the asset.

Dutyholders, through their major hazard analyses, are required to identify safety-critical elements (SCEs) whose failure will either cause, contribute to or, limit the effect of a major accident. In light of current knowledge of MAH (eg jet and pool fires, gas explosions) some SCEs may not now be entirely suitable or fit for purpose. This issue has, and is, being addressed through HSE's ongoing strategic inspection programme, duty holder re-evaluations of MAH and general upgrade of hardware and systems. This issue of SCE suitability was therefore beyond the scope of KP3.

KP3 has focused primarily on inspection of the maintenance management of SCEs and systems. That is, to inspect integrity management of SCEs and systems that are in place offshore to ensure that they will be available when required and will provide the expected level of reliability.

A2.2 Inspection methodology

KP3 was aimed at inspecting the effectiveness of the maintenance management of SCEs and systems on offshore installations. In carrying out the programme the HSE was required to achieve the following[3]:

- to use all OSD specialist resources to make an in-depth appraisal of duty holders' ability to manage the integrity of their installations in a manner that takes adequate account of health and safety;
- to identify deficiencies in maintenance and other activities that underpin life-cycle integrity;
- to use HSE influence and, where necessary, formal enforcement powers, to ensure that legal requirements are met and that any deficiencies threatening integrity are speedily remedied;
- to work with industry in a way that encourages good practice in integrity management, continuous improvement, and a minimisation of the potential for accidents.

This translates into the following two specific components:

- a 3-year inspection programme focussed on key integrity/maintenance management issues (KP3/3);
- coordination of other OSD topic/specialist work against the aim of the key programme.

Following 11 pilot inspections carried out during October 2003 and November 2003, the full programme was initiated. This was developed on a year-by-year basis using feedback and intelligence from inspection management teams (IMTs) and input from specialist inspectors.

It should be borne in mind that the KP3 inspections were effectively a 'snapshot' of the installation performance at the time of the inspection which could subsequently improve or decline.

A2.3 Inspection templates

To assist in ensuring focused inspections and a consistent approach by the inspection teams, templates were developed for both onshore and offshore use. The templates consist of question sets covering all aspects of safety-critical maintenance management including backlog, deferral, corrective maintenance, supervision and verification issues.

The questions were used as the basis for interviews both on and offshore, in which the effectiveness of all areas of SCE maintenance management was challenged. They were aimed at management and technical authorities (TA) onshore and offshore team leaders (OTL), and were made freely available to the industry on the HSE KP3 website at: http://www.hse.gov.uk/offshore/programme.htm.

A2.4 System tests

In addition, in order to obtain first-hand data on the physical performance of SCEs, a number of systems were identified which could be tested while offshore. It proved more practicable to test some systems, primarily for operational reasons. For example, the testing of emergency shutdown valves or blowdown systems would be likely to shut down production (with its associated hazards). However, testing of deluge or TR integrity could be carried out with minimal disruption or potential hazard.

A2.5 Traffic lights

The KP3 Steering Group devised a simple traffic light system to summarise the results from each inspection and to simplify the presentation of KP3 findings to inspectors and to the industry. Each section of the template is provided with a traffic light box for the inspection team to complete, as shown below.

NON COMPLIANCE/ MAJOR FAILING	ISOLATED FAILURE/ INCOMPLETE SYSTEM	IN COMPLIANCE/ OK	NOT TESTED/ NO EVIDENCE

The inspection team then 'scored' each section GREEN, AMBER or RED as appropriate. The definition of the traffic light colours is defined as follows:

NON COMPLIANCE/ MAJOR FAILING	*Non-compliance with legislation* *Major failing of system (hardware or management) or partial failure with a history of failure* *Minded to serve notice*

Issues in this category must be expressed in the letter to the dutyholder, eg:

(a) no system for authorising deferrals of SCE maintenance;
(b) complete failure of SCE to meet performance standard;
(c) multiple failure of SCE;
(d) no competence system for supervisors or TA's;
(e) no clear system for review of effectiveness of SC maintenance performance (PUWER Reg 5).

ISOLATED FAILURE/ INCOMPLETE SYSTEM	*Isolated failure of a well-defined system* *Incomplete procedures/systems.* *Partial failure of SCE, eg:* *a) fire pump starts but back up fails, or vice versa;* *b) ESDV closes two seconds longer than required by performance standard.*

Issues in this category should be expressed as recommendations in the letter to the dutyholder.

IN COMPLIANCE/ OK	*Tested or inspected but with no significant issues found* *Complies with regulations etc.*

NOT TESTED/ NO EVIDENCE	*Not tested or no evidence*

The function of the traffic light is to indicate failings and/or compliance for analysis and presentation purposes. Where enforcement action has been taken, the traffic light was scored amber or more usually red. These were then transferred to a matrix from which a picture of overall industry performance could be built up (see A2.9.)

A2.6 Reporting

During the offshore inspection feedback on any issues, key findings and good practices was provided to offshore management and safety representatives. Feedback was also subsequently provided to management onshore. All red traffic light issues, and some more critical amber issues, were communicated to the dutyholders, followed up by an inspection letter and enforcement action where appropriate.

A2.7 Inspection follow-up

As part of the KP3 inspection process, follow-up of all red traffic light issues by the KP3 inspection team or, IMT inspector was monitored by KP3 the manager and any subsequent changes to traffic light scoring was recorded. While some issues could be addressed relatively quickly others have required significantly longer, eg backlog or structural problems related to manpower can take some time to rectify. In the case of enforcement involving Improvement Notices a timescale would be imposed for completion.

A2.8 Consistency

The inspection programme involved nearly 40 Specialist and 25 IMT inspectors overall. To ensure consistency between inspections and assignation of traffic lights an analysis group was formed consisting of Specialist and IMT inspectors. They reviewed the reports and challenged traffic light assignations which appeared to be inconsistent with other inspections. Their analyses were referred back to the inspection teams for review and possible change where appropriate.

A2.9 KP3 matrix

All traffic lights were transferred to a matrix showing the inspection results for each installation as individual lines (Figure A2.1).

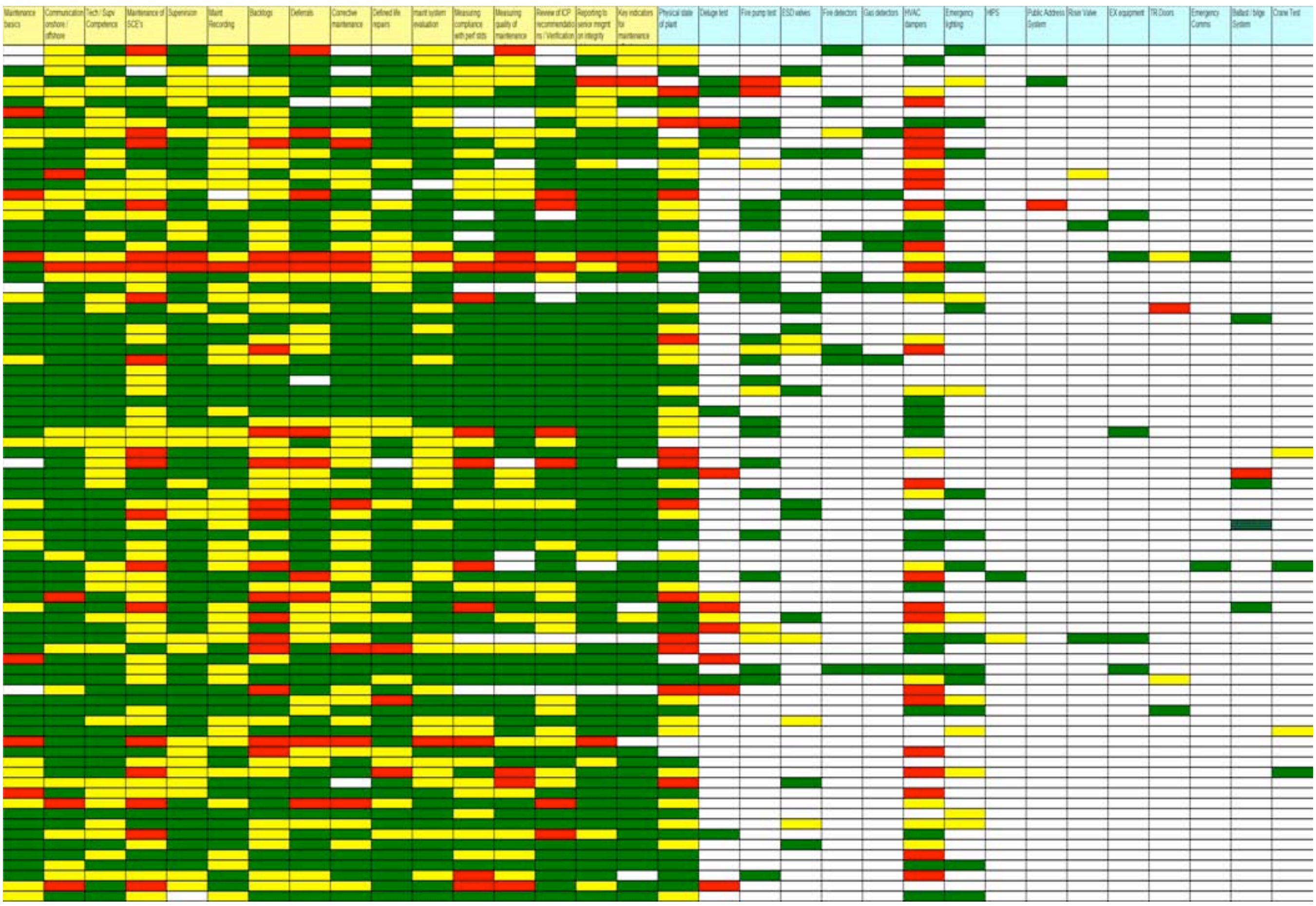


Figure A2.1 KP3 traffic light matrix

This format enabled areas of good and poor performance to be highlighted as the inspection programme progressed. It has proved to be a very powerful means of displaying and comparing industry performance.

By sorting the matrix (eg by dutyholder, installation type, ranking of red traffic lights) conclusions have been drawn concerning overall industry performance. In addition, by analysing the details of the inspection reports which lie behind the traffic lights, common themes related to areas of good and poor performance have been identified.

Appendix 3

Results

These results cover the period 2004 up to July 2007. There are 32 inspections included in this analysis for the 2006/2007 inspection year with a total of 36 to be completed by December 2007. The additional inspections are not expected to change the overall conclusions to a significant extent. Additional results from inspections going on at the time of writing will be added to the internet version of the report which will be updated as appropriate.

All traffic lights generated from KP3 inspections were recorded on a 'Traffic Light Matrix'. The matrix has been split here, to show Management System results (Figure A3.1) and System Tests results (Figure A3.2). The results of several further inspections are outstanding and will be included in the internet version of this report. They are not expected to change the main conclusions.

Issues related to management systems and system tests are discussed separately, as is Physical State of Plant (the left-hand column in Figure A3.2).

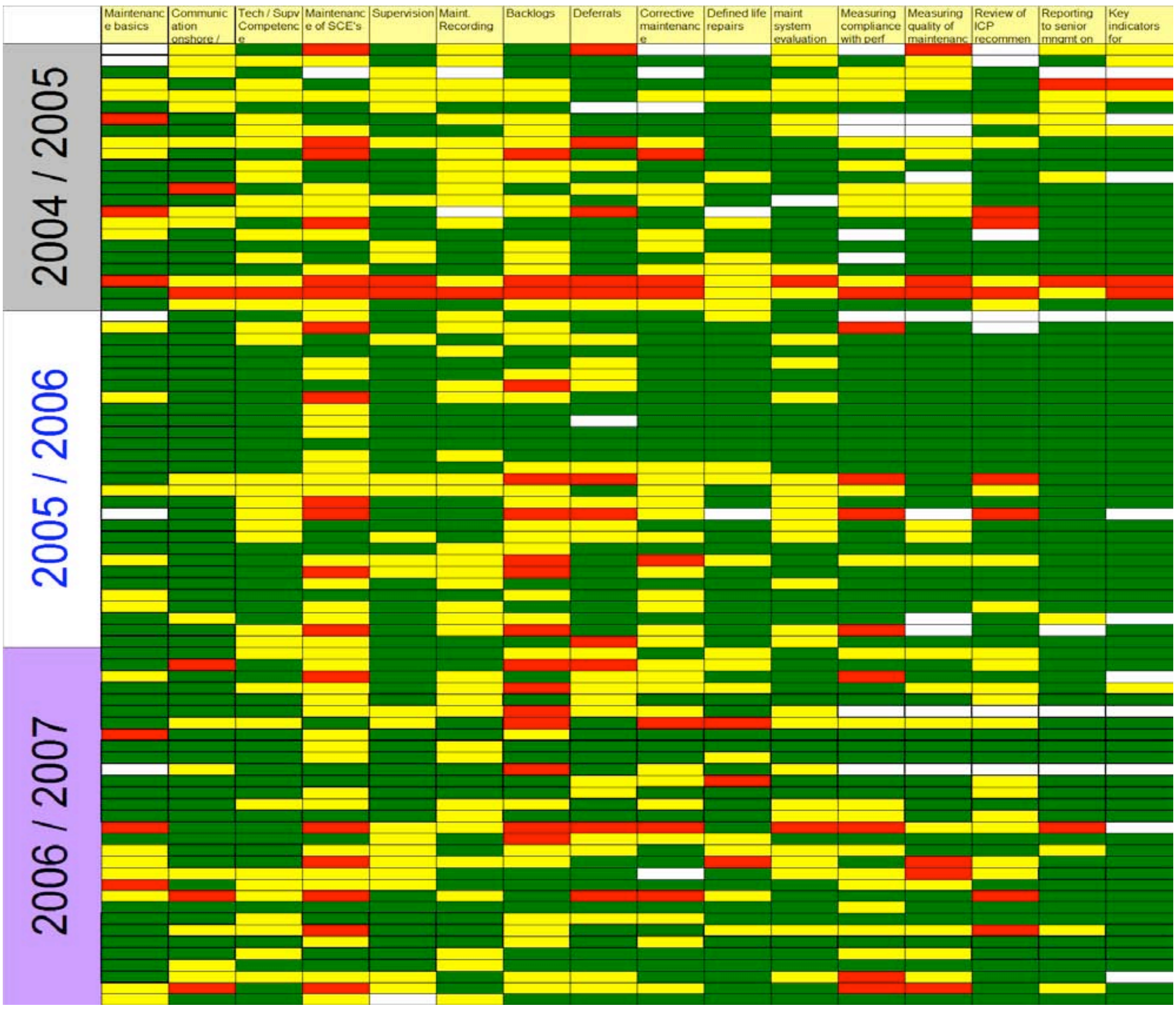


Figure A3.1 KP3 management system matrix

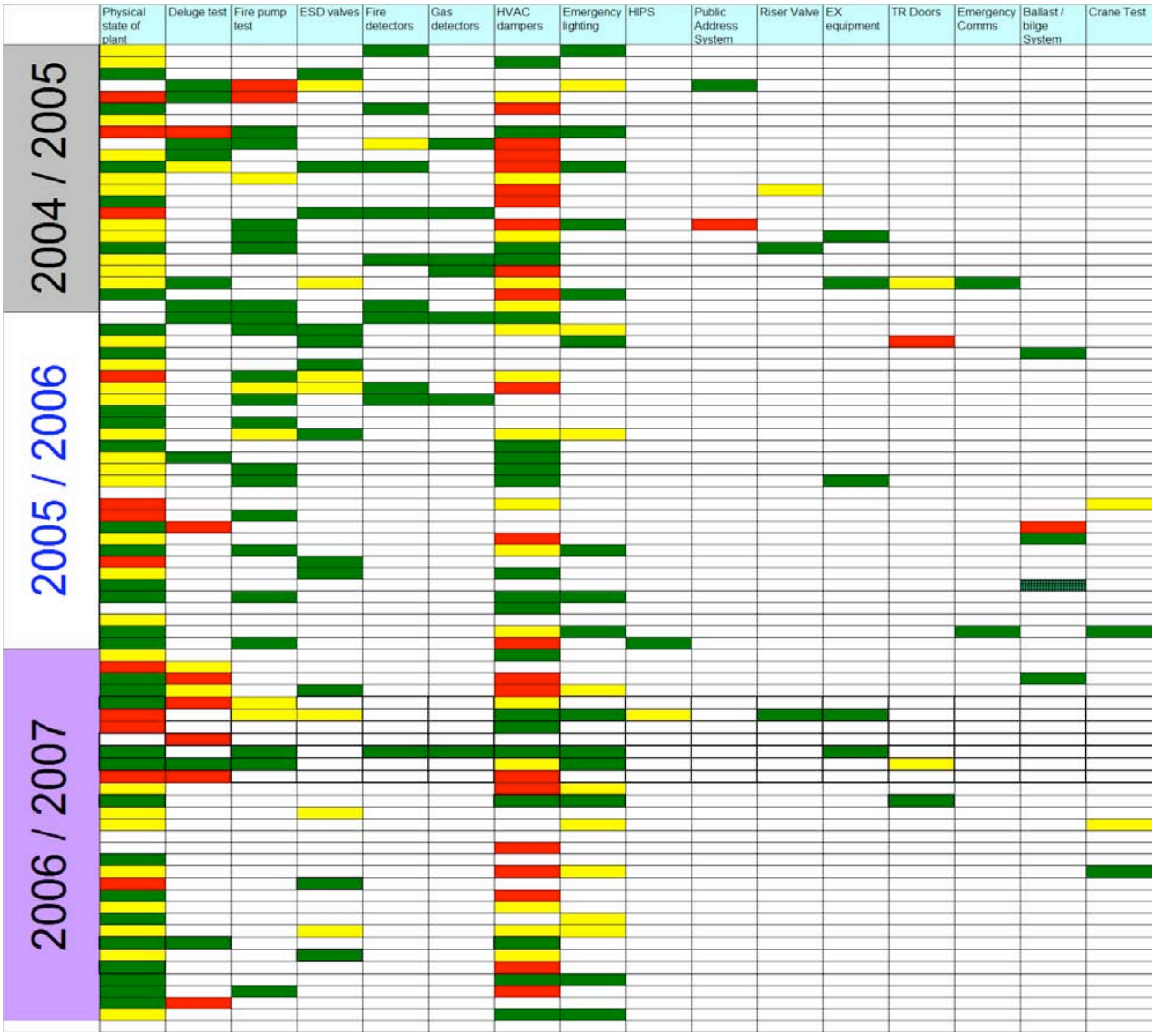


Figure A3.2 KP3 system test matrix

Each line of the matrix is numbered and represents an inspection. Several installations were inspected several times in light of ownership changes and KP3 follow-up. The matrix has been anonymised but each installation's traffic lights will be provided to their dutyholder together with pie charts showing the distribution of greens, ambers, and reds for each template element. This has already been carried out for inspections completed up to April 2006.

The internet version of this report will include a downloadable version of the numbered matrix as an Excel spreadsheet at: http://www.hse.gov.uk/offshore/information.htm.

Dutyholders will be informed of their installations number(s) and will be able to identify their platforms on this matrix and carry out their own analyses as required.

Completed traffic light template scripts form part of the overall inspection reports, which are not for publication. However, they have been analysed in detail by the Health and Safety Laboratory with the main conclusions summarised in this report. A finalised research report will be available, when all inspections have been included, at: http://www.hse.gov.uk/research/rrhtm/index.htm.[5]

Installations have not been ranked against another based on their traffic light scores. Consistency between inspection teams was addressed as far as possible by the Analysis Group but a level of subjectivity was inevitable as reliance on the inspector's opinion was an integral part of the process. Amber traffic lights in particular covered a range of performance, from bordering on green to bordering on red. Also, some elements of the matrix will be more significant than others in overall maintenance effectiveness and ultimately provision of barriers against MAHs. It was therefore considered that a direct ranking of one installation against another was inappropriate.

A3.1 Overall traffic light scoring

The overall proportion of green, amber and red traffic lights for management system is shown in Figure A3.3.

Proportion of red amber and green management system traffic lights assigned

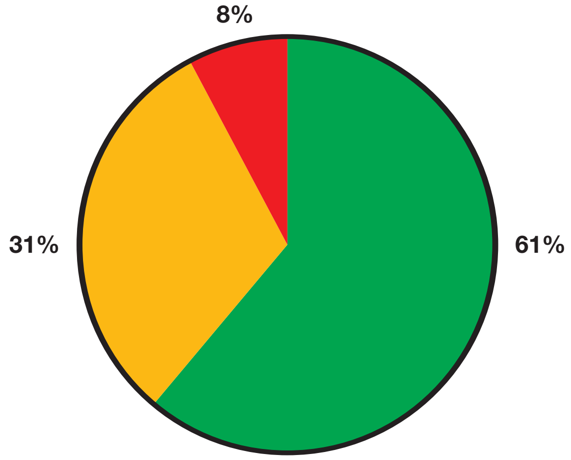


Figure A3.3 Overall traffic light scoring – management systems

It can be seen that the proportion of management system green lights (61%) assigned outweighs ambers and reds combined. However, the level of poor performance related to amber and red traffic lights (39%) was significant. The overall proportion of amber and red traffic lights (58%) for physical state of plant outweighed the number of greens (Section A3.1.2 below).

A3.1.1 Management system elements

Figures A3.1 and A3.2 above, show inspection traffic lights recorded in the order in which they were analysed (ie approximately in date order). Figure A3.4 shows the percentage of green, amber and red traffic lights scored during each year of the programme for the management system elements.

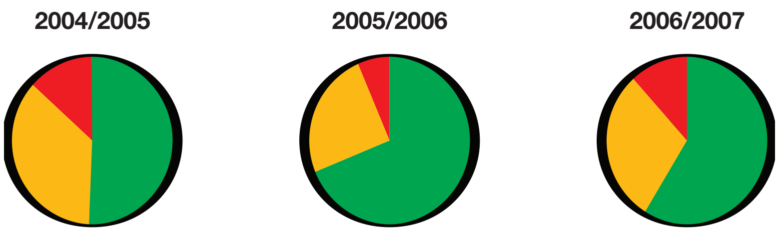


Figure A3.4 Yearly traffic light distributions (%)

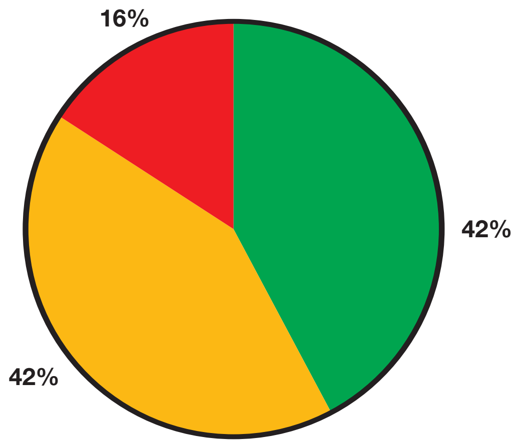
Year on year the proportion of green traffic lights assigned has been higher than amber plus red combined, with an improvement in performance in 2005/2006. The improvement in performance in 2005/2006 can be clearly see in Figure A3.1 where consistent good performance is apparent to the right of the corrective maintenance element. Over this period four mobiles were inspected (discussed below) and three fixed installations from a single company.

The number of red and amber traffic lights assigned over the latter part of 2005/2006 and 2006/2007 was similar to that of 2004/2005 with no overall improvement over the programme lifetime.

A3.1.2 Physical state of plant

This element was based on the inspection team's opinion of the overall condition of the installation overall ie including fabric, structure, safety-critical and non-safety-critical plant and systems. Figure A3.5 shows that over half of those reported (58%) were scored amber or red. Figure A3.2 shows that over the lifetime of the programme this was one of the poorer performing elements. However, towards its end there appeared to be a slight improvement in the number of greens scored.

Distribution of traffic lights for physical state of plant
Figure A3.5 Physical state of plant (%)



A3.1.3 System testing

Figure A 3.2 shows the range of system tests carried out during the inspection programme. Deluge, fire pumps, ESD valves and (TR) HVAC dampers were tested most extensively.

From 20 tests carried out on deluge systems 7 (35%) scored red, 3 (15%) scored amber and 10 (50%) scored green (Figure A3.6)

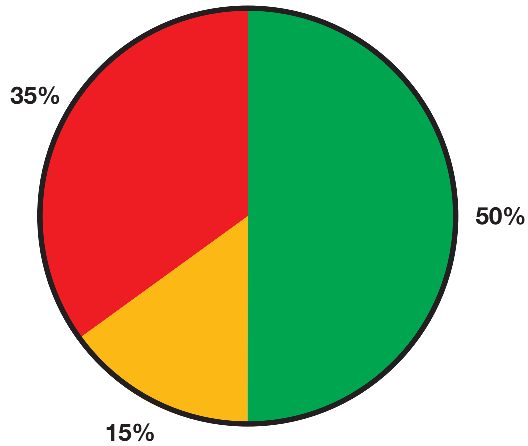
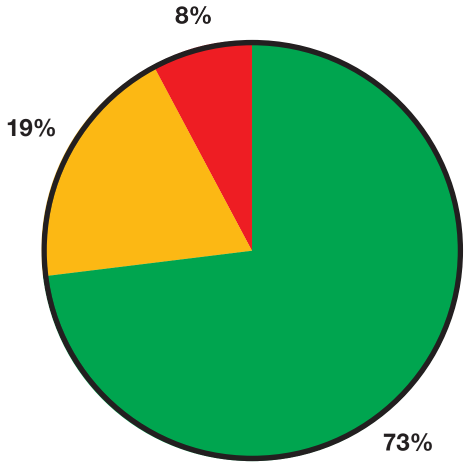


Figure A3.6 Deluge test traffic lights

From 29 fire pump tests carried out, 2 (7%) scored red, 5 (17%) scored amber and 22 (77%) scored green (figure A3.7).

Fire pump test results (%)
Figure A3.7 Fire pump test traffic lights



From 17 ESDV tests carried out, 0% scored red, 7 (37%) scored amber and 12 (63%) scored green (Figure A.3.8).

ESDV system tests results (%)

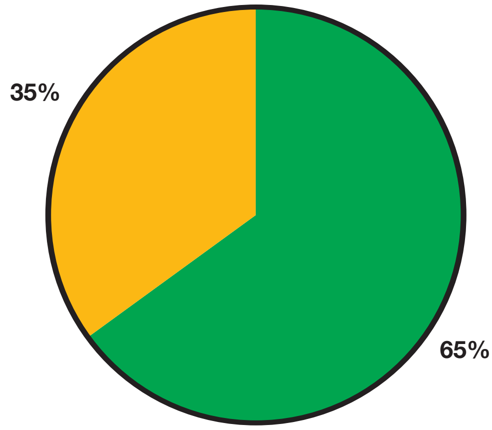


Figure A3.8 ESDV test traffic lights

TR HVAC was the most extensively tested system. The distribution of traffic lights recorded for HVAC system tests are 35% red, 29% amber and 36% green (Figure A.3.9). It can be seen from Figure A3.2 that there was no improvement in the test results for HVAC throughout the programme lifetime.

HVAC system tests results (%)

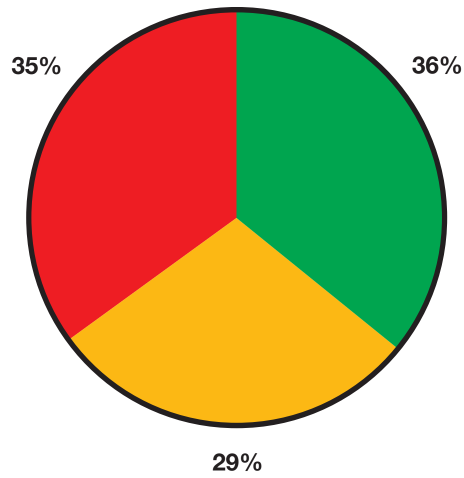


Figure A3.9 HVAC test traffic lights

A3.2 Management system traffic light ranking

Figure A3.10 shows the overall proportion of green traffic lights assigned across the 17 management system elements; green (61%) amber (31%) and red (8%).

Proportion of red amber and green management system traffic lights assigned

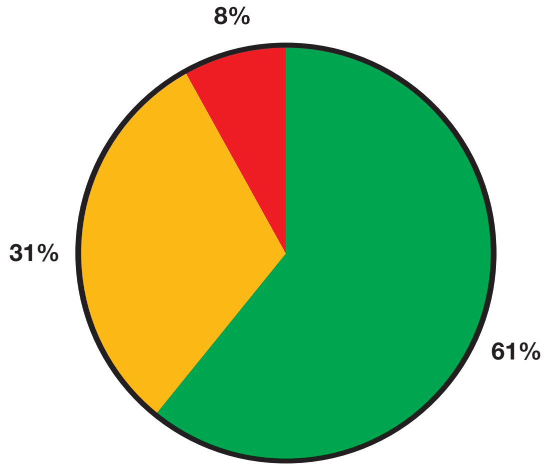


Figure A3.10 Overall traffic light scores

The number of green assigned was twice that of amber and 7.5 times those of red.

Figure A3.11 shows the distribution of red and amber lights across the management system elements.

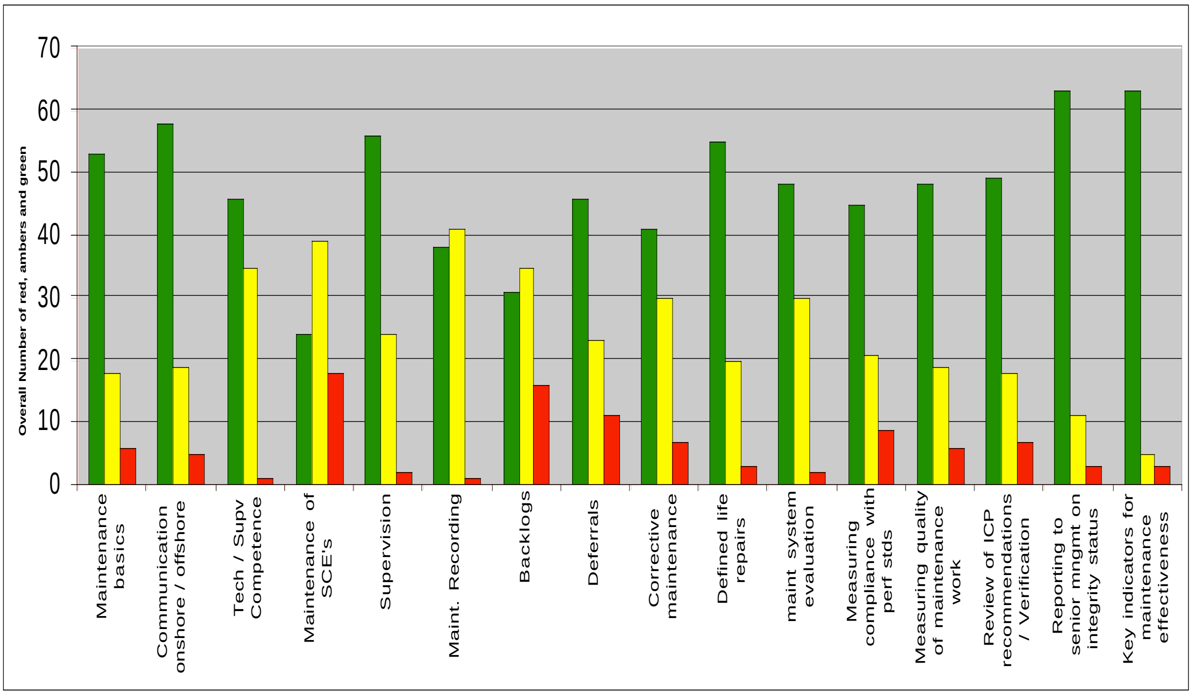


Figure A3.11 Distribution of traffic lights across management system elements

The elements with highest number of red and amber traffic lights are discussed below. Table A3.2 summarises the ranking of the top five elements for red, amber and red and amber assignations.

RANKING	RED	AMBER	RED+AMBER
1	Maintenance of SCEs	Maintenance Recording	Maintenance of SCEs
2	Backlog	Maintenance of SCEs	Backlog
3	Deferrals	Technical Supervision	Maintenance Recording
4	Measuring compliance with PS	Backlog	Corrective Maintenance
5	Corrective Maintenance	Corrective Maintenance	Technical Supervision

Table A3.2 Ranking of template elements

While the criterion for red traffic lights was clearly defined in the methodology as a 'serious' issue, potentially requiring enforcement, amber traffic lights inevitably covered a wider range of significance from higher than green to lower than red. For this reason more weight has been placed on red traffic lights ranking in the analysis. However, for both red and red plus amber traffic light ranking, maintenance of SCEs and backlog are the two weakest performing elments. For amber traffic lights alone, backlog is the fouth highest ranked with maintenance recording ranked second highest.

A3.2.1 Ranked green traffic lights

Table A3.3 and Figure A3.12 below show management system template elements ranked by green traffic light scores, with associated amber and reds. For 12 of the of the 16 management system elements, the number of green traffic lights exceeded the number of red and amber combined.

Reporting to senior mngmt on integrity status	Key indicators for maintenance effectiveness	Communication onshore / offshore	Supervision	Defined life repairs	Maintenance basics	Review of ICP recommendations / Verification	maint system evaluation	Measuring quality of maintenance work	Tech / Supv Competence	Deferrals	Measuring compliance with perf stds	Corrective maintenance	Maint. Recording	Backlogs	Maintenance of SCE's
63	63	58	56	55	53	49	48	48	46	46	45	41	37	31	24
11	5	19	24	20	18	18	30	19	35	22	21	30	41	33	39
3	3	5	2	2	6	7	2	4	1	11	9	7	1	16	17

Table A3.3 Green traffic light ranking

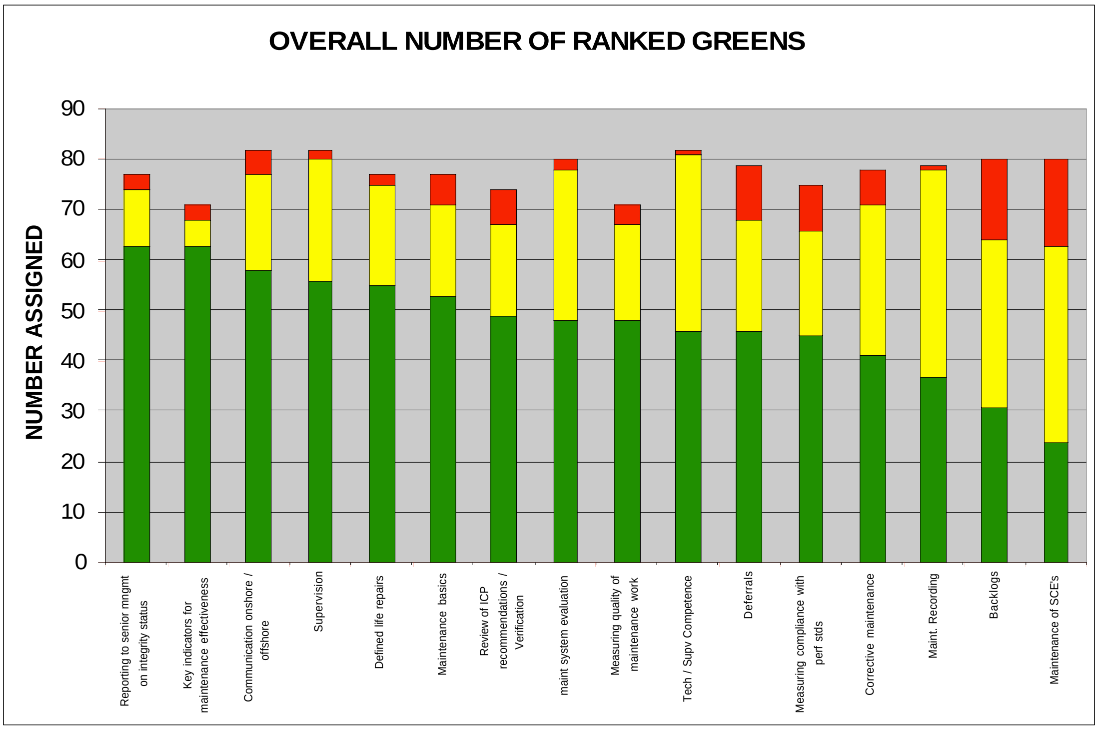


Figure A3.12 Green traffic light ranking

Several matrix elements have performed consistently well in relation to assignation of green traffic lights throughout the inspection programme, namely:

- reporting to senior management on integrity status;
- key indicators of maintenance effectiveness;
- communications between onshore and offshore;
- supervision;
- defined life repairs.

A3.2.2 Ranked red traffic lights

Table A3.4 and Figure A3.13 show management system template elements ranked by red traffic lights scored. The worst performing areas are:

- maintenance of SCEs;
- backlog;
- deferrals;
- measuring compliance with performance standards;
- corrective maintenance.

Maintenance of SCE's	Backlogs	Deferrals	Measuring compliance with perf stds	Corrective maintenance	Review of ICP recommendations / Verification	Maintenance basics	Communication onshore / offshore	Measuring quality of maintenance work	Reporting to senior mngmt on integrity status	Key indicators for maintenance effectiveness	Supervision	Defined life repairs	maint system evaluation	Tech / Supv Competence	Maint. Recording
24	31	46	45	41	49	53	58	48	63	63	56	55	48	46	37
39	33	22	21	30	18	18	19	19	11	5	24	20	30	35	41
17	16	11	9	7	7	6	5	4	3	3	2	2	2	1	1

Table A3.4 Red traffic light ranking

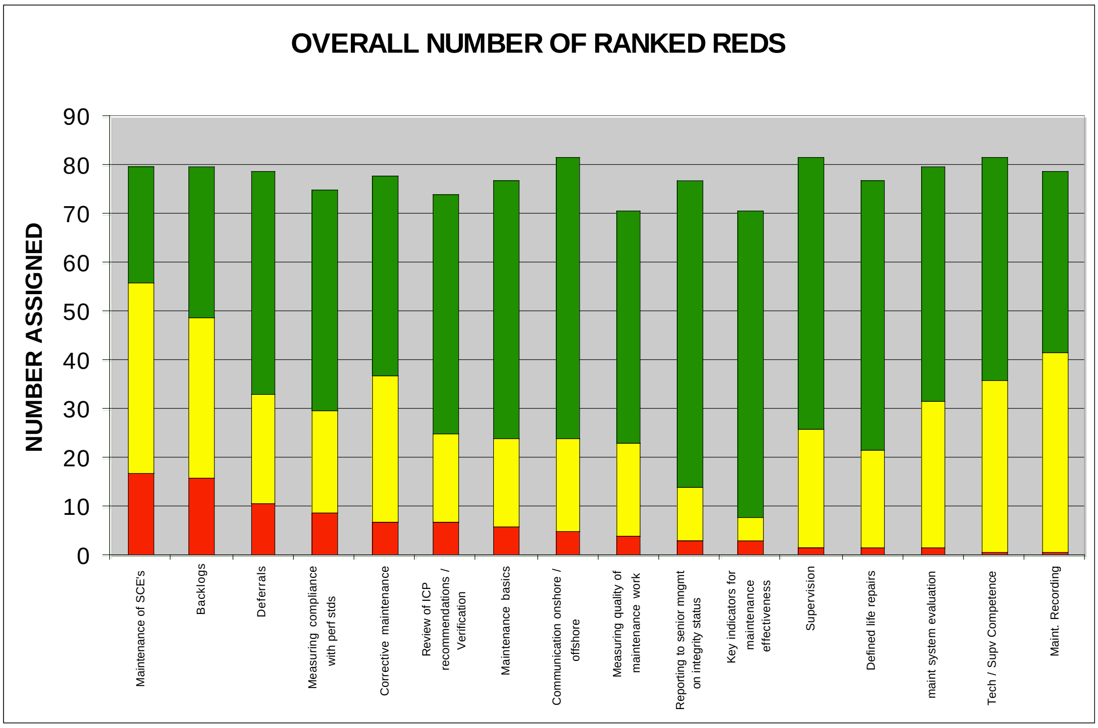


Figure A3.13 Red traffic light ranking

Reporting to senior management and key indicators for maintenance effectiveness performed the best overall with the lowest number of combined reds and ambers. Maintenance recording, technical supervision/competencies and maintenance system evaluation scored the lowest number of reds but also scored a relatively high number of ambers.

A3.2.3 Ranked amber traffic lights

Table A3.5 and Figure A3.14 show management system template elements ranked by amber traffic lights scored.

Maint. Recording	Maintenance of SCE's	Tech / Supv Competence	Backlogs	Corrective maintenance	maint system evaluation	Supervision	Deferrals	Measuring compliance with perf stds	Defined life repairs	Communication onshore / offshore	Measuring quality of maintenance work	Maintenance basics	Review of ICP recommendations / Verification	Reporting to senior mngmt on integrity status	Key indicators for maintenance effectiveness
37	24	46	31	41	48	56	46	45	55	58	48	53	49	63	63
41	39	35	33	30	30	24	22	21	20	19	19	18	18	11	5
1	17	1	16	7	2	2	11	9	2	5	4	6	7	3	3

Table A3.5 Ranked amber traffic lights

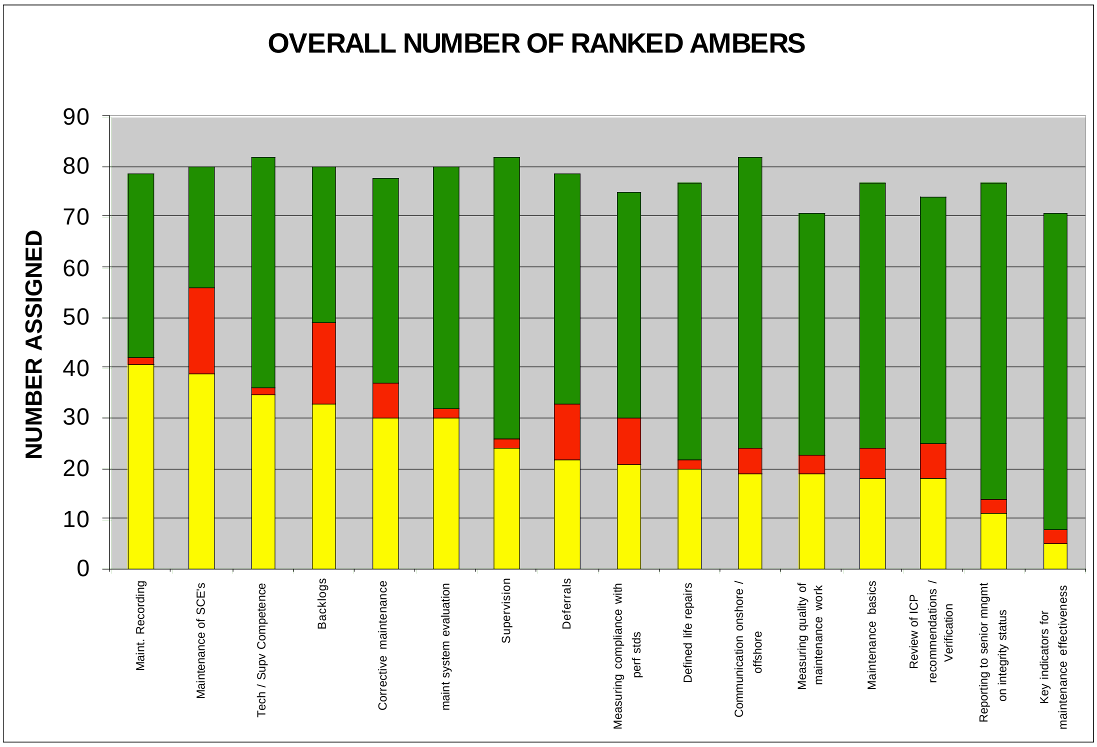


Figure A3.14 Ranked amber traffic lights

The four worst performing elements were:

- maintenance recording;
- maintenance of SCEs;
- technical supervision; and
- backlog.

Best performing elements in relation to number of ambers assigned were:

- key indicators of maintenance effectiveness;
- reporting to senior management;
- review of ICP recommendations.

A3.2.4 Ranked red and amber traffic lights

While serious issues giving red traffic lights required immediate attention, amber traffic lights covered a range of criticality from almost green to almost red. Table A3.6 shows management system template elements ranked for combined red and amber traffic lights plotted on Figure A3.15.

Maintenance of SCE's	Backlogs	Maint. Recording	Corrective maintenance	Tech / Supv Competence	Deferrals	maint system evaluation	Measuring compliance with perf stds	Supervision	Review of ICP recommendations / Verification	Maintenance basics	Communication onshore / offshore	Measuring quality of maintenance work	Defined life repairs	Reporting to senior mngmt on integrity status	Key indicators for maintenance effectiveness
24	31	37	41	46	46	48	45	56	49	53	58	48	55	63	63
39	33	41	30	35	22	30	21	24	18	18	19	19	20	11	5
17	16	1	7	1	11	2	9	2	7	6	5	4	2	3	3

Table A3.6 Red and amber traffic light ranking

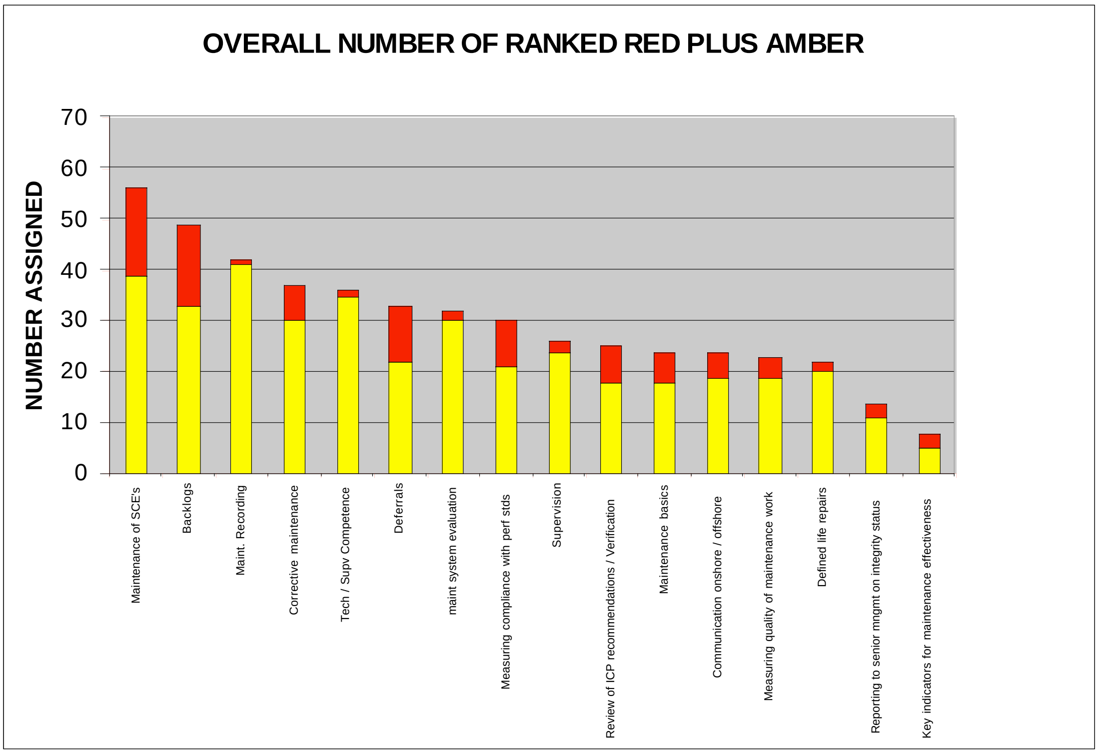


Figure A3.15 Red and amber traffic light panking

Worst performing elements were:

- maintenance of SCEs;
- backlog;
- maintenance recording;
- corrective maintenance.

Best performing elements were:

- key indicators of maintenance effectiveness;
- reporting to senior management.

A3.3 Performance by installation type

The traffic light matrix sorted by installation type is shown in Figure A3.16. Mobile installations, floating production and fixed installations are discussed separately below. Common themes related to good and bad performance across all installations are discussed in Section A3.3.

Here, floating production installations include both FPSOs and converted semi-submersibles.

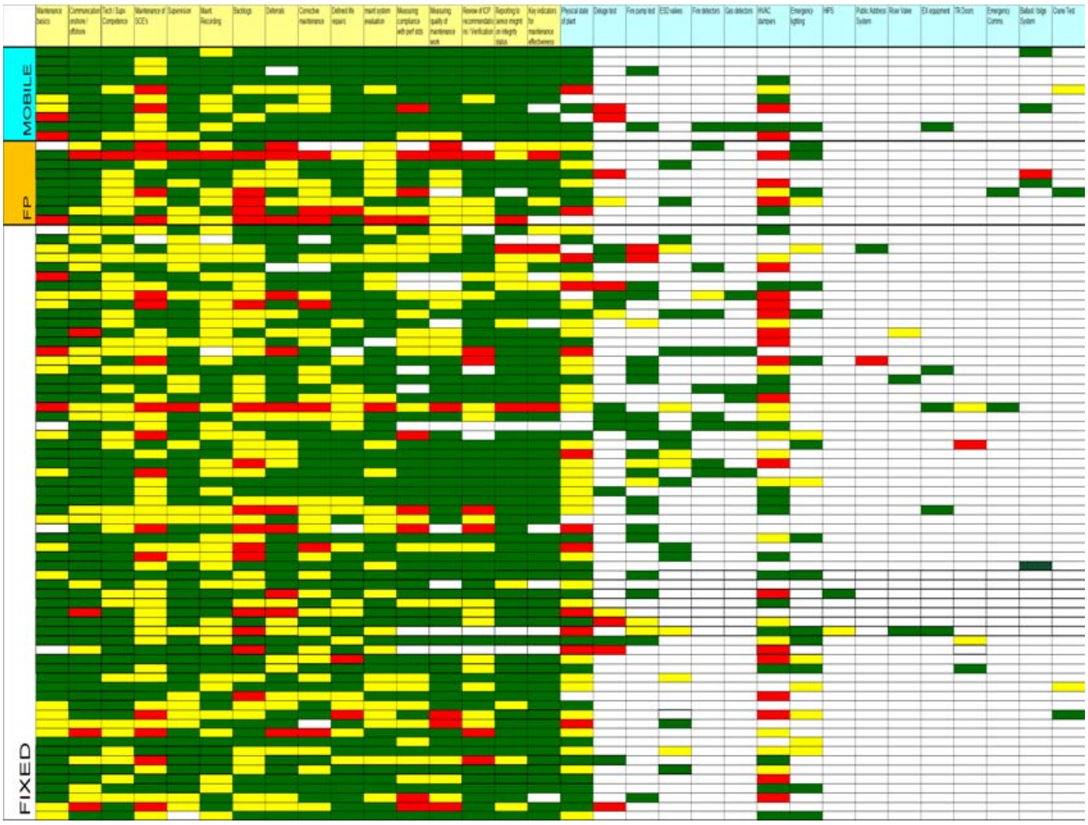


Figure A3.16 Comparison of performance by installation type

The performance of management system elements overall for mobile, fixed and floating production installations is shown in Figure A3.17

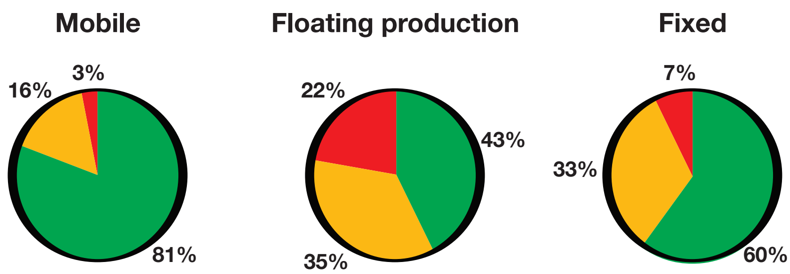


Figure A3.17 Mobiles (%) FPs (%) Fixed (%)

A3.3.1 Mobile installations

The ten mobile installations inspected performed better overall than fixed and floating production installations.

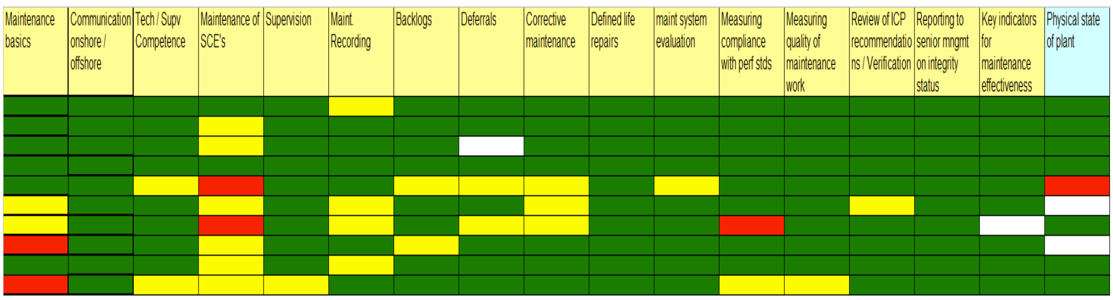


Figure A3.18 Mobile installations management system traffic lights

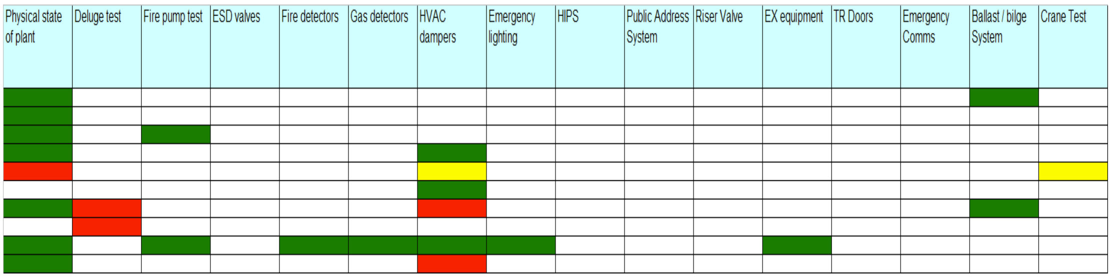


Figure A3.19 Mobile installations state of plant and system test traffic lights

Maintenance of SCEs, maintenance basics and maintenance recording were the worst performing areas. Eight of the ten installations inspected performed well in the area of backlog management, reporting to senior management on integrity status, communications, defined life repairs and key indicators for maintenance effectiveness. Poor performance in maintenance of SCEs was common to all other types of installation.

Both deluge systems tested that were assigned red traffic lights related to blocked nozzles. Two of the six TR HVAC systems tested were assigned red traffic lights.

A3.3.2 FP installations

Nine FP installations were inspected (Figure A3.20 and 21). The number of template elements where performance was poor exceeded that for fixed installations.

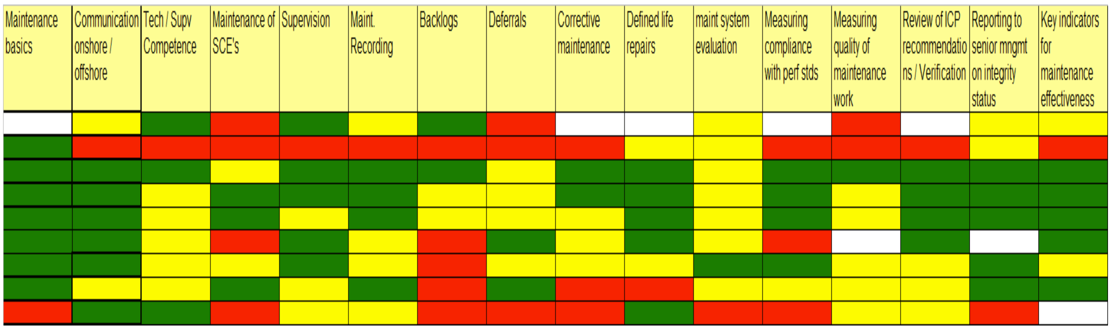


Figure A3.20 Floating production installation management system traffic lights

Figure A3.21 Floating production system test traffic lights

FPs generally scored more poorly than all other types of installation. Areas of poor performance were as follows:

- Backlog; 5 red and 2 amber
- Maintenance of SCEs; 4 red and 2 amber
- Deferrals; 3 red and 4 amber
- Maintenance system evaluation; 1 red and 7 amber
- Correctives; 3 red and 3 amber
- Measuring compliance with PS; 3 red and 1 amber
- Measuring quality of maintenance work; 2 red and 5 amber

The percentage of reds assigned to FPs was consistently higher than for fixed installations (Table A3.6) although the sample size of nine inspections was small.

	Maintenance of SCEs		Backlog		Deferrals		Correctives		Measuring compliance with PS		Maintenance system evaluation		Measuring quality of maintenance work	
FP % red/ amber	37% red	25% A	40% red	25% A	25% red	50% A	25% red	38% A	25% red	12% A	12% red	75% A	12% red	62% A
Fixed % red/ amber	20% red	48% A	19% red	50% A	14% red	27% A	8% red	38% A	10% red	26% A	2% red	33% A	8% red	38% A

Table A3.6 Comparison of percentage of red and amber traffic lights For FPs and fixed installations

Issues lying behind the areas of poor performance listed above are common to both FP and fixed installations. These are discussed in Section A3.4 below.

Key indicators of maintenance effectiveness and reporting to senior management again scored relatively well with maintenance of SCEs, backlog and deferrals scoring poorly.

A3.3.3 Fixed installations

Sixty four fixed installations were inspected to the writing of this report which comprised the majority of the inspections in the programme. There were wide variations in performance which could not be attributed to any single factor. However, the analysis of the background inspection reports has identified common themes which relate to specific issues. These are discussed below in relation to the individual matrix elements. They can also be applied to poorer performing areas for mobiles and floating production installations.

Figures A3 22 and 23 shows fixed installation traffic lights

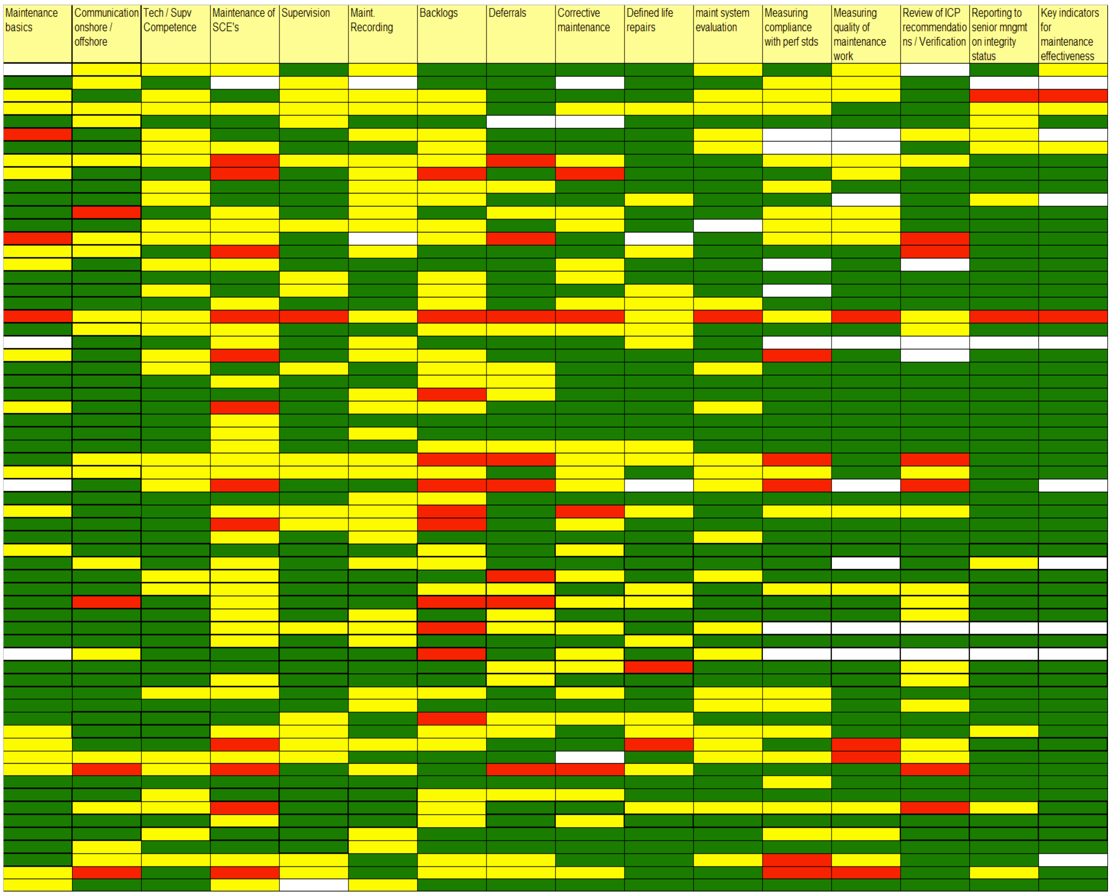


Figure A3.22 Fixed installations management system traffic lights

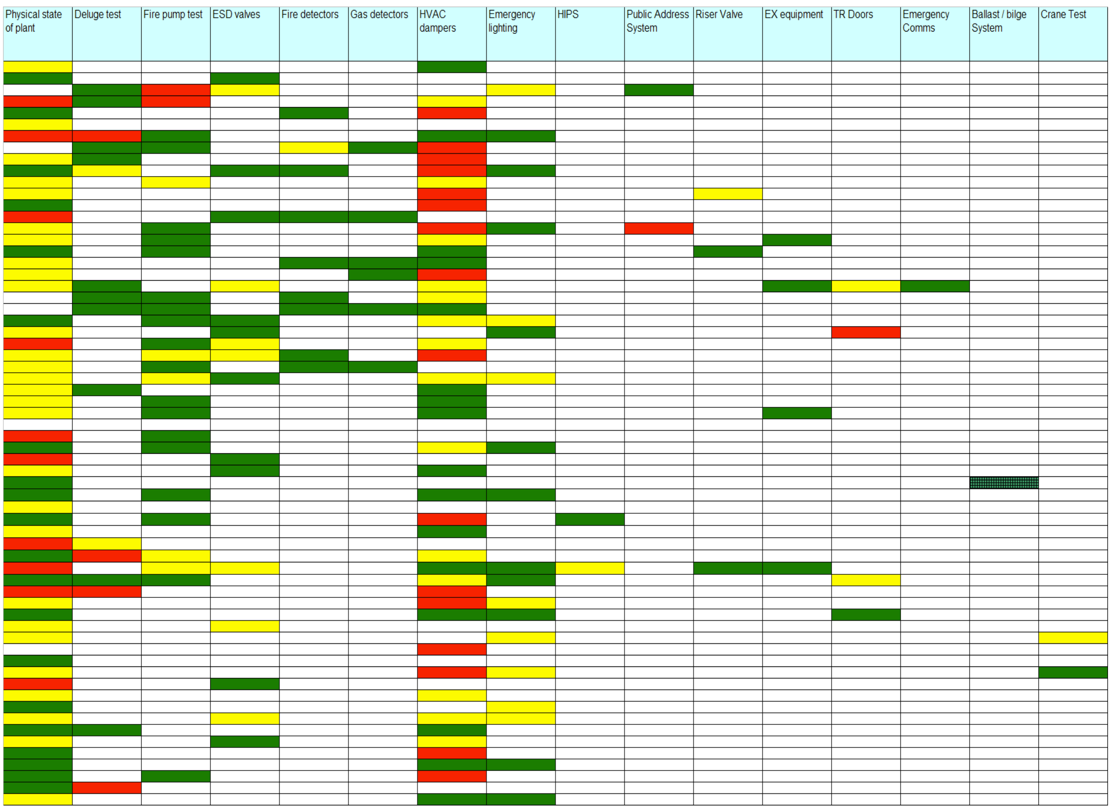


Figure A3.23 Fixed installation system test traffic lights

Green traffic light ranking (Figure A3.24) is very similar to the overall ranking with key indicators of maintenance effectiveness and reporting to senior management being the best-performing elements.

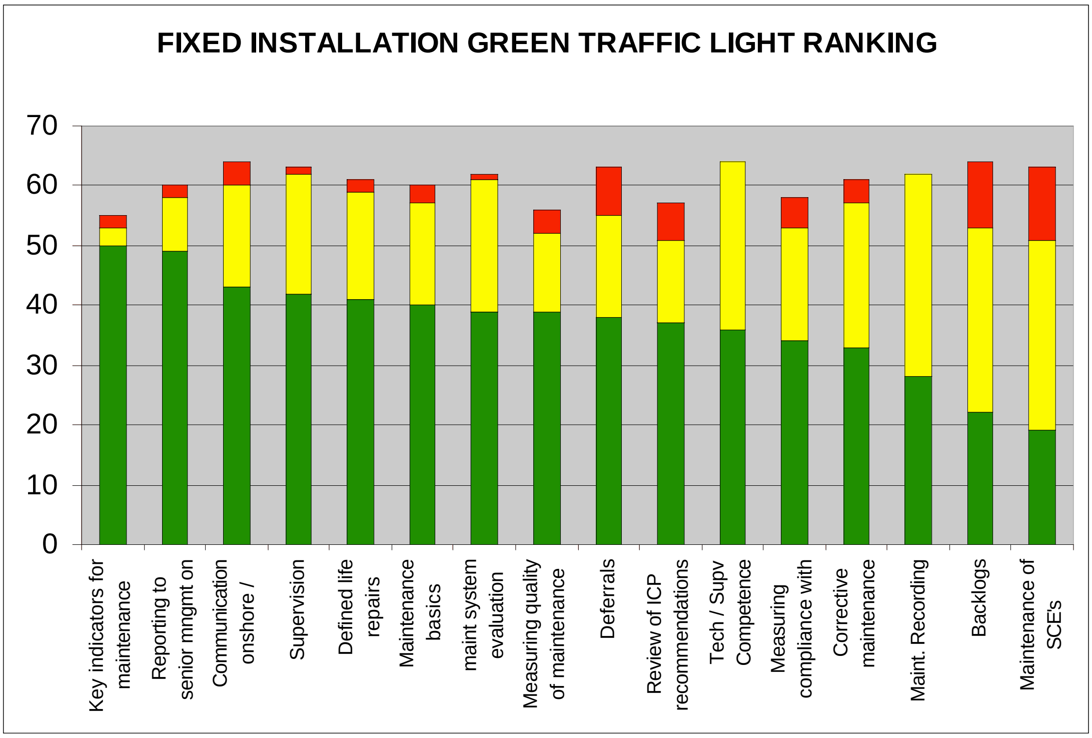


Figure A3.24 Fixed installation green traffic light ranking

Red traffic light ranking for fixed installations show in Figure A3.25 gives maintenance of SCEs, backlogs, deferrals and review of ICP recommendations with the highest scores.

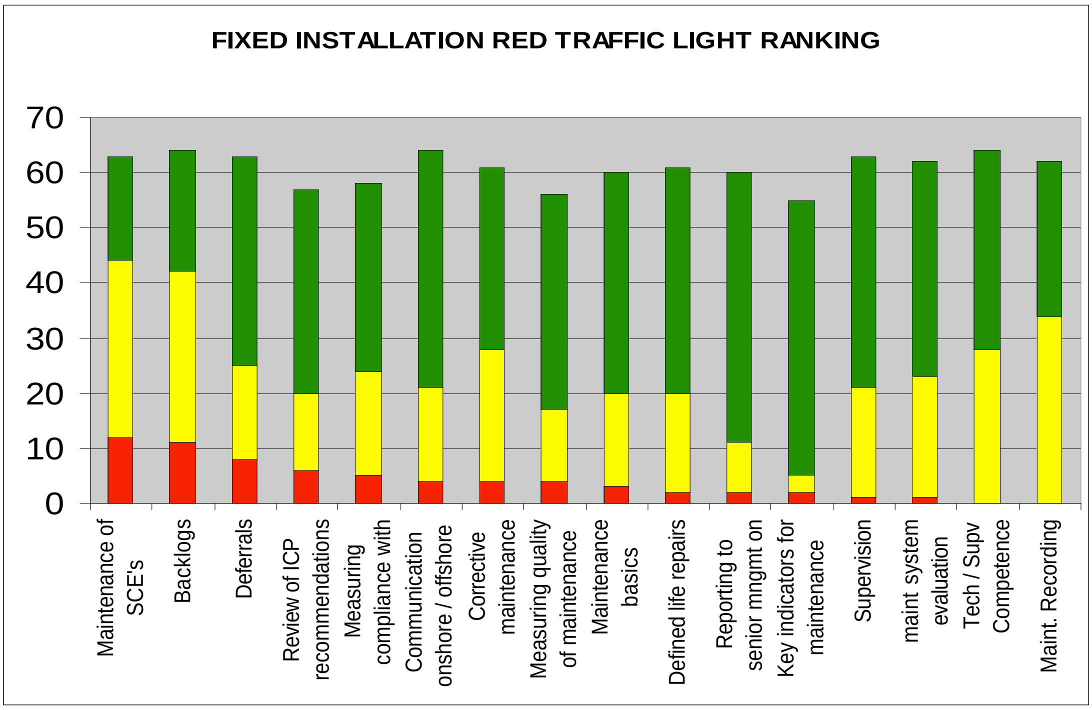


Figure A3.25 Fixed installation red traffic light ranking

The two best performing elements in terms of highest number of greens, and lowest number of combined red and ambers were reporting to senior management and key indicators for maintenance effectiveness, having the highest number of greens and lowest number of reds and ambers.

Amber traffic light ranking for fixed installations show in Figure A3.26 gives backlogs and maintenance of SCEs with the highest scores. The third and fourth ranked elements, maintenance recording and technical supervision/competence, were based ambers with only one red assigned in each case.

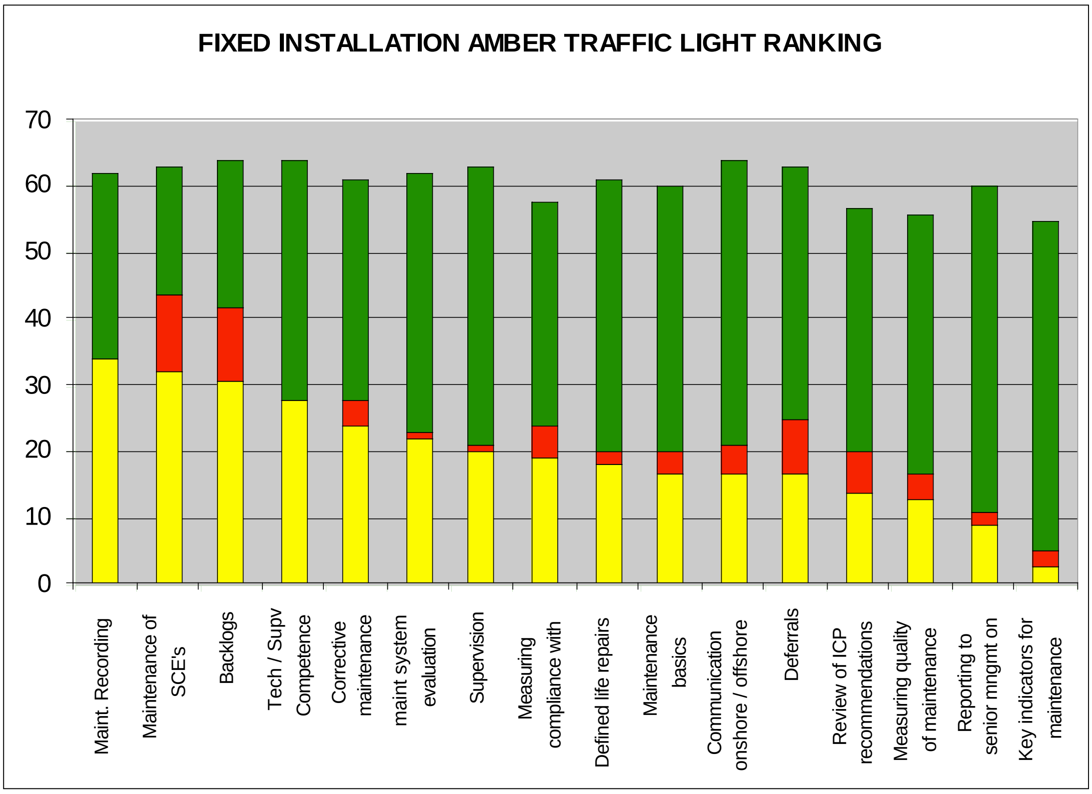


Figure A3.25 Fixed installation amber traffic light ranking

The above ranking of the top four elements for both red and amber traffic lights reflects the performance of all installation types combined. However, for fixed installations alone review of ICP recommendations is ranked fourth rather then correctives.

A3.4 Issues behind areas of poor performance

This section is based on the HSL analysis of inspection reports[5]. The template elements discussed below are the most poorly performing in relation to assignation of red and amber traffic lights throughout the inspection programme. They are common to both fixed and floating production installations, and to a lesser extent mobiles. The issues are those occurring most frequently across the inspection reports.

A3.4.1 Maintenance of safety-critical elements and measuring compliance with performance standards

Work orders (WO) were found to contained a statement of, or reference to, the relevant SCE performance standard (PS) in slightly less than 50% of the installations and acceptance criteria for function tests in just below 60% of the installations inspected. Failure to meet a PS was recorded on MMS but the amount of information entered on the system was often insufficient quality and detail to be of use.

The review and implementation of risk controls and specification of contingency/mitigation measures occurred on the minority of installations inspected. Formal review processes involving onshore TAs were not always in place. The generic nature of performance standards, which were not measurable or auditable, in some cases prevented specification of clear and achievable function test criteria.

A3.4.2 Backlog

The computerised maintenance management systems in use differ, with some systems allowing a window for implementation rather than a specific date after which a backlog is raised. The window was typically one month but was often related to the maintenance intervals. The latter specification can result in inappropriately long 'windows' for critical equipment.

Reporting systems were found to measure performance in different ways with some systems reporting the number of outstanding work orders rather than actual hours, thus causing distortion of backlog figures.

Backlog levels ranged from approximately 150 hours to a worst case of 26 000 hours. The maximum figure quoted covered non-routine maintenance only with the total backlog (including planned maintenance) higher still.

The split between safety-critical and non-safety-critical planned maintenance was not always clearly defined. An example was seen of 60 000 hours of which 15 000 hours related to safety-critical maintenance (planned and corrective). This data covered seven installations including NUIs but was being managed under a single maintenance management system.

The majority of installations prioritised maintenance on safety-critical equipment. However, in some cases, lower priority safety-critical corrective maintenance (eg fabric maintenance, emergency light fittings etc) was not being liquidated effectively.

Separation of inspection management from planned maintenance was common, potentially gave a distorted view of backlog. For example, outstanding inspection of EX equipment was not included in backlog figures but in inspection data, which was not reported as part of the MMS.

There were examples of maintenance deferrals with questionable justification leading to reduced backlog figures.

For non-routine corrective maintenance, generally all outstanding work was considered as backlog. Reactive (corrective) work often appeared to be managed at the expense of preventative maintenance. Where breakdowns were rectified immediately they were not included in maintenance management data, with only corrective backlog being reported. This gave a distorted picture of the reliability of the plant.

Common causes

Lack of bed space was identified as a significant cause of backlogs on a large number of installations. The situation could also be exacerbated by project and construction work resulting in competing demands for very limited bed space. Another major issue was the lack of access to equipment due to the pressure to continue production. Backlog, including safety-critical work (eg ESDV tests) and remedial work resulting from corrosion damage reports, required shutdown to complete. Management of work and prioritisation of tasks during scheduled shutdown was also identified as a problem area. On some installations, shutdown had been delayed resulting in increased backlog.

A number of installations reported difficulties in recruitment and/or retention of experienced technicians (mechanical, electrical, instrumentation). Companies were therefore compelled to employ less experienced technicians. Completion of work orders took longer than planned, due to the need for supervision of new personnel. As a result, rates of backlog liquidation were reduced.

Misalignment of the tour patterns of core crew (2 weeks on, 3 weeks off) and maintenance support team (2 weeks on, 2 weeks off) was considered to be causing difficulties on some installations.

Lack of planning and prioritisation or effective management of backlog in corrective maintenance was reported. Increases in corrective maintenance, due to ageing equipment, were also noted on some installations.

Backlog reduction measures

Campaign maintenance appeared to be used extensively as a means of reducing backlog. Some dutyholders expressed reservations about the effectiveness of this method, as campaign teams tended to lack familiarity with the installation. In addition, problems with bed space and a high handover to core staff of unfinished work orders were experienced.

Discrete work programs in areas such as ex inspection were, however, regarded as effective on some installations.

Several companies are moving away from campaign maintenance as teams have been seen to pick off 'easy targets' and at the same time tie up core personnel. The new strategy is a 'spread out' campaign crew that completes work orders and at the same time develops platform competence, enabling them to carry out more complex tasks without supervision.

Other methods included a concerted effort, both onshore and offshore, to reduce backlog by the provision of flotels, appointment of additional supervision and technicians and dedicated backlog teams.

A number of dutyholders recognised that backlog could be reduced by improvements in planning and scheduling. Proposals for software tools, pilot schemes, risk-based work selection, workshops and additional training have been described. Root cause analysis of major plant failures was also proposed to prevent 'fire-fighting'.

A number of installations had recently upgraded their computerised maintenance management systems. This involved the transfer of numerous planned maintenance routines. Rationalisation and removal of duplicate procedures have resulted in significant reductions in backlog work orders in some cases.

Comparison by installation type

There were significant variations in the levels of backlog on fixed installations. With some exceptions, backlog numbers on the 'amber/red' installations appeared to be reducing slowly, but levels remained high.

Backlog levels on the floating production, storage and offloading vessels (FPSOs) also varied. Red/amber traffic lights were generally assigned where backlog levels remained static due to lack of targeted resources.

With the exception of one installation, backlog levels on the mobile units inspected were low. Staff appeared to be well aware of backlog levels, which were discussed regularly. Maintenance management system on one mobile unit displayed all outstanding maintenance activities every time an individual logged onto the system. Backlogs were also reviewed monthly by senior staff and additional resources allocated where required. The amber traffic light resulted from a postponement of preventative maintenance routines in order to undertake repair and survey work. Management were aware and appeared to be taking appropriate action.

A3.4.3 Deferrals

Deferral procedures for safety-critical elements (SCE) appeared to be well understood, which was not always the case for non-safety-critical items.

Deferral levels ranged from zero to worst cases of 196, 153 and 139 WOs with the majority of installations reporting less than 40 items of deferred work.

A trend is difficult to determine but records indicated that levels were reducing or were consistently low. Company policy of strong challenges from onshore technical authority discouraged requests for deferrals on some installations.

Deferrals were increasing on other installations due to, for example:

- delays in planned shutdown;
- competing demands (such as project work) during the shutdown period;
- adverse weather conditions (preventing or reducing time on installation).

The split between deferral of safety-critical and other work was not evident in a number of cases. Some installations differentiated between deferrals of planned and corrective maintenance, others did not allow deferral of reactive work.

Planned shutdowns were generally the focus for planning and executing deferred maintenance activities.

Authorisation

Where green 'traffic lights' have been allocated, deferral of safety-critical work was generally authorised by onshore technical authorities, with the involvement of the independent competent person, where required. This was not, however, always implicit in the deferrals procedure. Cases were noted where deferrals were not sent to ICP, who should have been involved (eg ESDV's and PSV's).

On a number of installations, the authorisation procedure was dependent upon the category of the item in question. Offshore authorisation was permitted for lower category deferments or non-safety-critical items. An area of concern related to decisions to defer tests being taken at the wrong level on some installations.

Additional issues

Some installations recorded uncompleted maintenance (during shutdown or campaign maintenance) as deferred work items, instead of backlog. This process led to artificially low backlogs, which do not reflect a 'true' backlog status. Deferrals were issued to bring the work into line with the next scheduled shutdown or visit to platform. Concern was expressed over perceived pressure to defer safety-critical equipment maintenance during shutdown due to the large 'man hour' demand from project work.

It was felt that submission of deferral requests on the maintenance 'due date' indicated a pressure to prevent non-compliances rather than assess each request (and particular piece of equipment) on its merits.

Although generally required by the deferral procedures, evidence of risk assessment and identification of additional measures was limited in some cases. In addition, identified measures were not always implemented following deferrals (eg increases in inspection frequency).

The competence of staff carrying out risk assessments was unclear and some TAs were not trained in risk assessment. On other installations, no formal discipline advice was available for input to RAs. The deferral procedure adopted by one dutyholder failed to assess the cumulative risks arising from multiple safety-critical equipment failures. Operational risk assessments were looked at in isolation.

It was found on one installation that, where there was no history of past performance, it was assumed that the SCE in question had passed the last three assurance routines. Therefore the perceived risk factor defaulted to a lower value. In addition, subsequent to approval, the time period for the deferral could be altered.

Recording of deferrals

As with backlog, there is no single method across the industry of recording and managing deferrals. Some dutyholders recorded deferred items within backlog figures, others separated them out. Tracking of deferrals and their management and review by senior management was in some cases used as a KPI. Where target dates are moved from deferred equipment it is considered essential that there is management oversight.

Trigger point

Many of the installations reported no formal action date for the consideration of deferral. In some cases, this was due to consistently low levels of deferred maintenance. The trigger point for action on deferrals varied across dutyholders.

Comparison by installation type

Deferral procedures (and allocated traffic lights) differed fairly significantly throughout the fixed installations and it was therefore difficult to determine a trend. Deferral procedures (and allocated traffic lights) on FPs appeared to be improving over time.

Mobile units in general had very low deferral rates. As a result of this, some operators did not have a formal system in place to record the process involved in the deferral of maintenance. Where maintenance of a SCE was deferred (drilling programme at a critical point, for example), the majority of dutyholders carried out risk assessment and introduced additional safety measures, where required.

A3.4.4 Corrective maintenance

Issues such as insufficient staff and bed space were frequently raised as contributing factors to the issues related to corrective maintenance. These are common to issues in other template elements including backlog and deferrals.

Consultation with onshore TAs and provision of technical support was patchy. Formal procedures for initiating risk assessment were absent in several cases leading to absence of or inadequate implementation of mitigation measures and additional barriers.

The level of breakdown appeared to be a primary problem. This impacted on the overall ability to manage planned maintenance. An additional issue related to reporting only corrective backlog rather than ongoing levels of breakdown. This gave a distorted picture of the reliability of the plant and the level of maintenance resource required to keep it running and safe.

A3.5 General issues

A3.5.1 Communication

Figure A3.26 shows the management system matrix ranked by the number of red and amber traffic lights with no weighting for traffic light colour. Poorest performance in relation to the number of reds and ambers assigned is shown at the top of the matrix with worst performing elements (again in terms of reds and ambers) ranked from left (poor) to right (good).

Each numbered column to the left of the matrix indicates a company, with all installations inspected identified. This illustrates the variation in performance within companies of different types. It does not include all companies included in the programme as several had only a single installation inspected.

Overall, reporting to senior management on integrity status and key indicators of maintenance system effectiveness performed best and maintenance of SCEs and backlog performed worst.

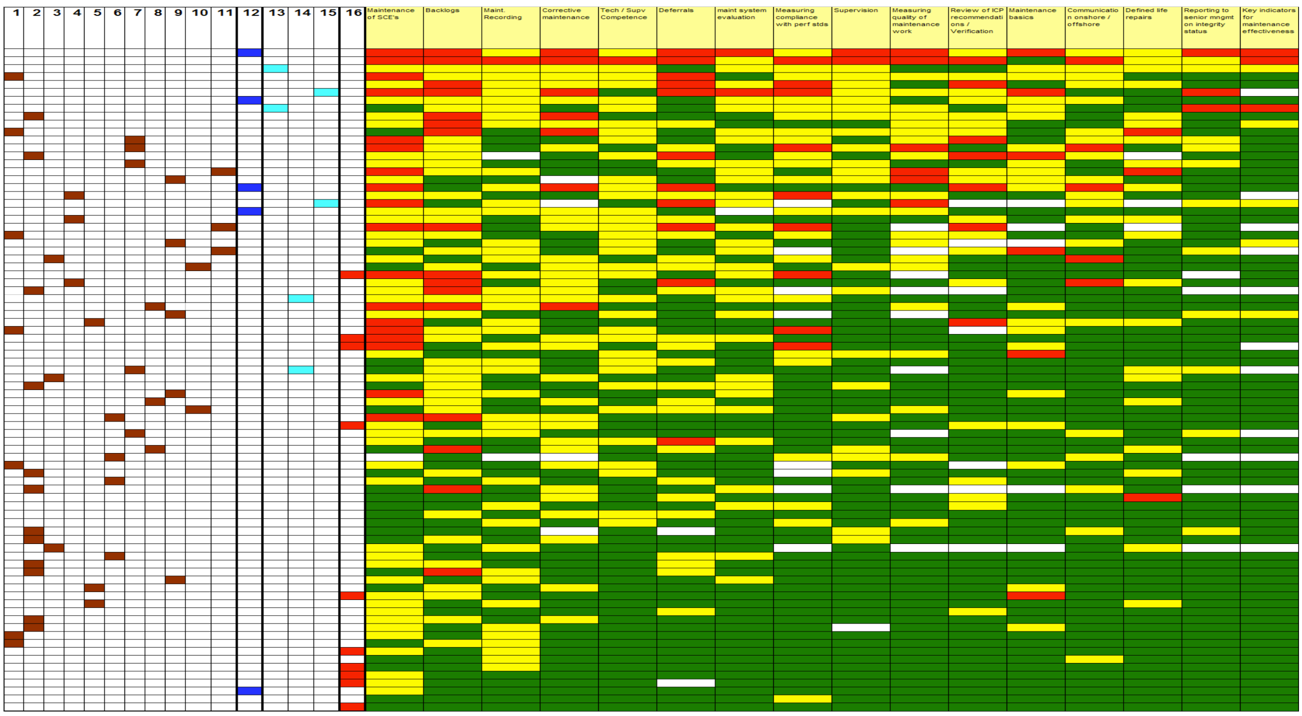


Figure A3.26 Matrix ranked by red and amber management system traffic lights

Colour coding for the left-hand columns is as follows:

INTERNATIONAL	
INTEGRATED SERVICES	
SMALL LEAN	
DRILLING	

International companies

In the international company category a wide variation in performance can be seen within individual companies. Performance within a particular organisation can range from very good to poor (columns 1, 2, 3, 5, 6, 7, 9) or, grouped over a particular part of the matrix (columns 4, 8, 10).

Within the integrated services category (column 12; a single company) a single installation accounted for the two worst performing traffic lights. The second, better performing inspection was carried out to follow up red issues arising in the initial inspection. The level of improvement can be clearly seen.

The best performing installation in this category, which was one of the best performing overall, is an older platform with low production system pressures and rates. Within the 'small lean' company category (columns 13 to 15) performance range is smaller with pairs of installations grouped closer together.

Columns 16 show results for mobile installations covering a range of companies. While mobiles generally performed better than other categories a wide variation in performance can be seen between them.

Health and Safety Executive

Key Programme 3

Asset Integrity Programme