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# A Benchmarking Study on Asset Integrity and the Issues of Ageing Plant in the Chemical Industry and the Challenges of PSM Implementation across Global Sites

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Guidance on best practice for Process Safety exists in the form of HSE documents and literature from the Process Safety Leadership Group (PSLG), but in general the high hazard industry's approach to it has been somewhat disjointed. In order to address this, HFL Risk Services, together with the Chemical Industries Association and the National Skills Academy for the Process Industries embarked on what was the first ever Process Safety Management benchmarking programme for UK COMAH sites. The focus of the benchmarking programme was Asset Integrity Management, one of the most fundamental aspects of an effective PSM system and a topic that is of concern on account of the continuing use of ageing plant. Further studies were later carried out across Europe, independently of the UK stakeholders, with 18 sites taking part in all. Whilst is it recognised that countries may operate under differing regulatory requirements and that sites may have differing cultures it emerged that, irrespective of geography or language, the same safety issues arose within benchmarked sites in each of the separate global production plants. The challenge for any dispersed global organisation is to operate a world class process safety management system appropriate for all sites regardless of geographical location or language.
It was clear from the research that although there were several instances of world class performance in terms of PSM, there were weaknesses in other areas, most notably Process Safety Leadership.
This paper examines the key results of the benchmarking programmes, their implications for the chemical industry as a whole and provides examples of best practice in implementing and sustaining effective safety management system.

## 1. Introduction

Most would agree that an effective Asset Integrity Management programme is a prerequisite for continued safe operation of any chemical process plant. However, the challenge is not only to ensure that containment systems remain intact through use of appropriate inspection, testing, maintenance and repair strategies but that those strategies are implemented by competent and motivated personnel, and that they remain suited to the equipment, age and condition over time. Not surprisingly then, this is becoming increasingly difficult to achieve for those companies that are having to operate plant well beyond planned retirement dates, with fewer people, brought about by growing financial pressures in the face of fierce global competition.
Such is the problem in the eyes of the regulators that adherence to best practice in relation to Process Safety Leadership, Asset Integrity Management and Competence Management are now hot topics and subjects for close examination by inspectors of high hazard manufacturing sites.
In order to gain a deeper understanding of the extent of the perceived problem, HFL Risk Services embarked on what was the first ever Process Safety Management benchmarking programme for UK COMAH sites.
The first phase of the programme focussed on Asset Integrity Management and was carried out in collaboration with the Chemical Industries Association and the National Skills Academy for the Process

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Industries, with support from the Health & Safety Executive. Further studies were later carried out across Europe, independently of the UK stakeholders, with 18 sites taking part in all.
The auditing process was based around current guidance produced by the US Center for Chemical Process Safety (CCPS, 2007) and was prepared independently of, but mapped to, COMAH guidelines. A scoring system was also developed to allow assessment and prioritisation according to the POPMAR model set out in HSE's guidance document HSG65 (HSE, 1997).
It was clear from the results of the study that although there were several instances of world class performance in terms of Process Safety Management, there were weaknesses in some areas, most notably Process Safety Leadership and approaches to Continuous Improvement.

## 2. The decision to benchmark

In light of knowledge gained following investigations into incidents over recent years, regulatory bodies and industry stakeholders within Europe and the USA have developed an abundance of guidance on Process Safety Management and the systems necessary for prevention, control and mitigation of major accidents. But experience has shown that when it actually comes to application of the guidance, industry's approach has been somewhat disjointed.
It was for this reason that HFL Risk Services embarked on the benchmarking programme. The exercise itself took 4 months to complete and involved representatives from manufacturing sites of differing size, from multinationals to SMEs, with different areas of specialism. The participating companies were specifically selected to give a balanced and fair representation of the UK chemical industry as a whole in terms of size, organisation and complexity.
Assessments were later carried out at a further six hazardous installations in the UK and Europe, three of which are regulated under the Seveso Directive, (Council Directive, 1996). The additional data obtained from the European sites supported the initial findings and it was encouraging to see that the conclusions drawn were not unduly influenced by local differences.

## 3. Assessment methodology

Information was collected using HFL Risk Services' proprietary auditing tool, INSIGHT Lifecycle®, between the months of November 2010 and April 2012. Designed and developed over a number of years to quickly and accurately pinpoint areas for improvement, the tool comprises a series of question sets aligned to relevant legislation and internationally recognised best practice guidance – in this case the US Center for Chemical Process Safety (CCPS, 2007) Guidelines for Risk Based Process Safety and UK COMAH and HSE guidelines.
The auditing process generated over 6,000 data points on which to base the results of the assessment and findings were supported by observations and documentation as appropriate. Questions covered aspects associated with Process Safety Culture, Competence and Asset Integrity Management, giving due consideration to the chemical process, plant and equipment, procedures and people. Scores were then mapped to the POPMAR model set out in HSE's guidance document HSG65, i.e. against Policy, Organisation, Planning & Implementation, Monitoring, Audit and Review.
In order to ensure that procedures and custom and practice were adequately captured, the questions were asked of a cross-functional team at each site. Team members included managers, supervisors and operatives.

## 4. Initial observations

The results of the benchmarking exercise were more or less in line with expectations and consistent with the findings and recommendations published in the reports following the Buncefield (Buncefield Major Incident Investigation Board, 2008) and Texas City (Baker JA, 2007) (U.S. Chemical Safety and Hazard Investigation Board, 2007) investigations. Both recognised inadequate maintenance and testing as a contributing factor to the ensuing accidents.
On one level, the results from the activity were very encouraging – in fact performance was world class in some instances. Areas that scored particularly strongly involved technical aspects. The technicians and operators responsible for the day-to-day operation of the plant were competent in their areas of expertise. They had a clear understanding of what needed to be done to maintain integrity and undertook their roles with confidence. Organisation, Planning & Implementation and Monitoring aspects therefore scored highly.
Conversely, scores against the Policy, Auditing and Review elements of POPMAR were low, indicating that more needed to be done. Leadership and Administration elements were generally weak suggesting a lack of understanding or input from senior management and board members when it came to PSM policy.

Instead there appeared to be an over-reliance on those at the coal face to address issues relating to site safety, despite the fact that organisations rather than individuals are ultimately responsible for safety.
Interestingly, but perhaps not surprisingly, the scores across all companies were higher in those areas where more prescriptive legislation and clear guidance exists, e.g. aspects covered by the Pressure Equipment Directive (Council Directive, 1997) or BS EN 61511 (British Standards, 2004) or where there was a clear business driver such as the need for specific training in process operations for example. In these instances, company requirements were clear and appropriate procedures were in place.
As far as actual procedures were concerned, companies generally scored more highly in Design, Inspection, Mechanical and Control & Instrument Maintenance, and Maintenance Planning, with Management of Change and Failure Reporting, scoring particularly well in most cases. Policy, specifically with regard to Asset Integrity, Identification of Critical Equipment, Assessment of Degradation Mechanisms and competence of maintenance personnel, on the other hand, could be improved upon against the guidance.
In the absence of clear polices, some companies are falling into 'compliance mode' and failing to set out clear objectives and targets for Process Safety Management. This means that resources are not always being directed to where they might be most needed for the business and little improvement can be gained from measurement metrics (KPI's) since they will not necessarily drive behaviour in the most appropriate way.

## 5. The impact of ageing plant and the need for policy deployment

The term term 'Ageing' is often associated with time in service but the two are not necessarily related. 'Ageing' in the context of plant and equipment is a specific term that refers to the accumulation of damage and the increasing likelihood of failure over time. There is no defined period for the onset of ageing and even new plant and equipment can exhibit signs of ageing if the design is not suited to the process or environmental conditions. The challenge then is to remain focused on critical equipment ensuring that the degradation mechanisms are well understood and that the inspection and maintenance strategies remain matched to changing conditions.
Evidence of ageing is routinely picked up for equipment falling under the Pressure Equipment Directive. The inspection of pressure equipment including vessels piping and safety devices is tightly regulated and requires Written Schemes of Examination (WSE's) to be prepared and followed by a competent person. The competent person is required to look for and report on signs of degradation, recommend appropriate remedial actions to avoid failure, and prevent the use of any equipment identified as unsafe following examination.
The results of the benchmarking study revealed that standards for examination of pressure equipment were consistently high but regimes in place for other equipment often lacked the same rigour and some plant operators failed to look beyond the boundaries of specific regulations to ensure mechanical integrity. It should be remembered that storage tanks and vessels not covered by the Directive can be just as prone to failure, leading to loss of containment of hazardous substances with potentially disastrous consequences. Internal or external corrosion can occur due to environmental factors and the contents can also be responsible for corrosion, particularly where conditions are variable. Ultimately, walls can become thin leading to cracking or they can relent as a result of mechanical damage such as denting.
Statistically, a loss of containment of hazardous substances is more likely to occur via piping or pipework elements but surprisingly these systems are often excluded from inspection, even under insurance-based Written Schemes of Examination (WSE). When considering what to inspect, criticality assessments must not be over simplistic and consider the process system in its entirety.
Those involved in developing and implementing inspection and maintenance programmes must fully understand the system boundaries and capture all equipment that could lead to loss of containment of hazardous materials or energy in the event of failure – remembering that even failure of a water line can lead to loss of hazardous materials or energy if the water is required for essential services.
The very devices that are designed to protect containment systems against failure are also not immune to failure and checks for condensation, fouling and calibration inaccuracies should always form part of an inspection regime.
A prominent theme from the benchmarking process was a lack of detail in high level policies covering Asset Integrity. The high scores, as predicted, were consistent with HSE hot topics. Equally, issues relating to pressure equipment and safety devices were well understood and managed accordingly. Whilst this is highly commendable, the lack of clear policies for other areas of the operation can lead companies down the path of reactive compliance. Instead of setting out their own programmes of testing and inspection, companies are allowing themselves to be regulated into compliance.

Self-regulation allows companies to determine what needs to be done, where and when in accordance with budgets, but the impetus to improve performance should be led from the top with senior management and board members becoming involved in policy development and rollout.
If an Asset Integrity Programme is to be sustainable and focused a systems based approach to inspection must be adopted. Many companies participating in the benchmarking programme believed they were already doing this. During the assessments, however, it became evident that in the majority of cases this only applied to 'high risk' process plant and equipment.
As a minimum an examination scheme should stipulate all of the components within the system. It should state which parts of the system are to be examined and which are not. The type of examination required should also be specified and reference should be made to relevant procedures, including inspection and testing to be carried out on any protective devices. The minimum frequency of examinations should also be fixed. But remember, inspection should not just be left to the technical experts. Perhaps the simplest forms of inspection are regular 'eyes on' type inspections, which can identify many of the issues at an early stage before they are allowed to escalate into a catastrophic failure. For example, you don't need expensive thermographic surveys to identify poor insulation if there are weeds growing out of lagging – this is a good indication of water ingress issues.
Policy deployment helps to bring all this together by providing a sustainable structure or framework to work to. The formalisation of policy and procedures in this way obviates the reliance on experience, which was uncovered during the benchmarking audits, and will demonstrate regulatory compliance.

## 6. The challenges facing global process safety management implementation

The UK benchmarking exercise for asset integrity management highlighted common areas for improvement across the participating sites, especially in relation to the need for company policies and guidelines where specific legislation is not in place to ensure compliance with national standards. It was felt that introduction of company guidelines would be even more difficult for multi-national organisations with differing regulatory requirements and standards applying to different sites, depending on location, and a mix of cultures and values.
In order to help understand this aspect, the benchmarking programme was extended to cover additional sites across Europe. As with the UK based work, the process began with a training day for senior management, focusing on a common understanding of PSM and Critical Risk Control Systems. The training programme had been developed in line with the new UK Cogent Industry Training Standard for Process Safety Leadership and workshop activities focused on a review of Major Accident Hazards across the participating sites; identification of Critical Risk Control Systems; and developing a risk-based approach to PSM.
Benchmarking activities were undertaken at the individual sites in autumn 2011 and three key Risk Control Systems were assessed: Process Safety Culture; Competence Management; and Asset Integrity Management.
What transpired was that, whilst some sites performed better than others in certain technical areas, common management issues emerged once again, irrespective of geography. There was an absence of clear policy and sites were failing to set out objectives and targets for Process Safety Management. Again, without clear polices in place then the value measurement metrics, audit and review was undermined.

*Table 1: General Observations*

| POPMAR | General Areas for Improvement |
|---|---|
| Policy | •• Require specific policies covering process safety communications, competence management and asset integrity management |
| | •• Policies to set out own programmes for communication, training and inspection, testing and maintenance aligned to standards (where appropriate), risk and business case, rather than allowing them to develop through regulation / interventions by the regulator |
| Organisation | •• Roles and responsibilities to be clearly defined, setting resources and competency requirements |
| | •• Improved company / facility standards to provide greater transparency and avoid over reliance on individuals |
| Planning & Implementation | •• Communication of safety critical information, from leadership down |
| | •• Recognition of training needs for operations and maintenance personnel |
| | •• Register of training needs, critical activities, competence assessment |
| | •• Registration and identification of critical equipment (i.e. other than pressure equipment and safety instrumented systems) based on risk, e.g. main plant items, piping, supports etc. could be improved |
| | •• Improvements required in the inspection and testing of secondary and tertiary containment systems |
| | •• Hangers, drains and flooring need to be evaluated as part of a structural survey, this is not always the case |
| | •• Control of maintenance spares for critical systems could be improved |
| | •• Handover to operations following maintenance could be improved in some cases |
| | •• Redundant structures should be included in structural surveys especially where failure could be a precursor to a major accident |
| Monitoring | •• KPIs used to monitor effectiveness of programmes but not in all cases and not always visible throughout the organisation |
| | •• Information not always reviewed / correctly interpreted and acted upon |
| Audit | •• Generally, audits do not systematically examine all relevant / critical aspects, i.e. in scope and depth, to provide meaningful information for review |
| Review | •• Reviews do not consider whether or not the programmes are delivering what the business needs in all cases |

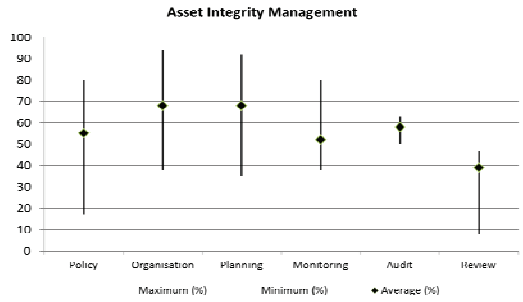


*Figure 1: UK scores for Asset Integrity Management against POPMAR model*

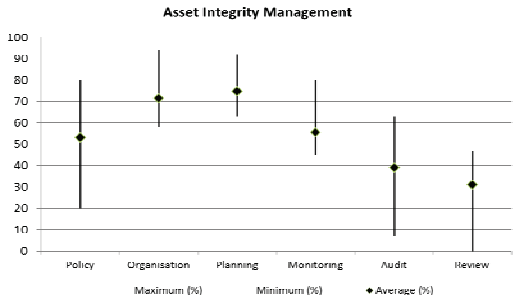


*Figure 2: Group scores for Asset Integrity Management against POPMAR model*

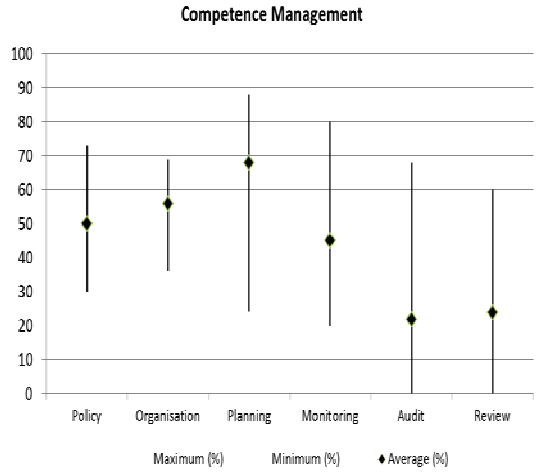


*Figure 3: Group scores for Competence against POPMAR model*

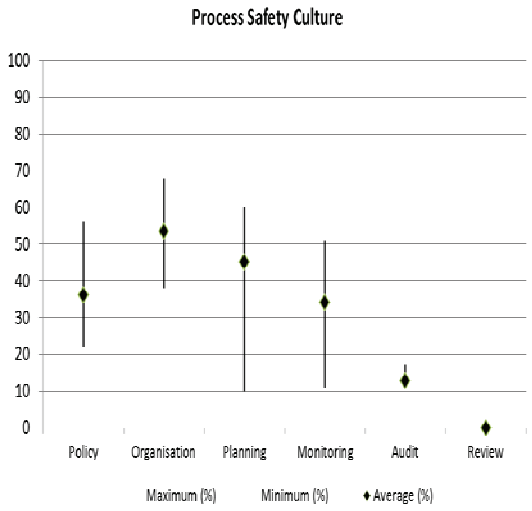


*Figure 4: Group scores for Culture against POPMAR model*

## 7. Overall conclusions

The results of the benchmarking exercises and workshop activities underlined a number of factors relating to the implementation of key Risk Control Systems. In order to meet the needs of the business, organisations need to develop and implement corporate policies, objectives and targets aligned to those needs. In this way they will be able to determine the scale of their own success. Monitoring of PSPIs at both site and group level will be central in confirming that key Risk Control Systems are operating as they should. In accordance with the recommendations identified, the organisations that took part in this exercise will be performing regular site and group audits to ensure compliance with local procedures and corporate policies. Periodic reviews will also take place in order to confirm that the business' needs are maintained.

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