MAKING PROCESS SAFETY A TOPIC FOR THE BOARD ROOM

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Recent major accidents in the Process Industry including those at Texas City, Buncefield and Deepwater Horizon, have highlighted the critical role played by senior managers. Effective leadership is essential if companies are to develop a positive safety culture that remains constantly vigilant towards the risk of process safety hazards. In the UK the HSE has made leadership a key priority and is supporting a cross industry programme to develop and deliver training focussed towards board members with responsibility for safety performance.

This paper will explore the leadership failings that contributed to recent major accidents, and the cost of these to both the company reputation and the individuals involved. Key issues will be discussed that can lead to improved leadership in the major hazard industries, including sites operating under the COMAH Regulations in the UK. These will include; attitudes and decisions of senior manager affecting the safety culture of the organisation, reinforcing the importance of safety by personal example, thorough understanding of major accident hazards and key risk control systems, investigating process safety incident and near misses to find the underlying causes, developing world class safety management systems, and identifying weaknesses in these systems using targeted performance indicators.

The author will base this paper on the development of a training standard for 'Process Safety Leadership' involving a cross industry 'expert panel' chaired by the CIA. Training of CEOs and senior executives in compliance with this standard was then carried out from late 2011, with courses organised by the National Skills Academy for the Process Industry. Feedback from these courses and the key attributes needed for effective leadership will be discussed.

KEYWORDS: Process Safety, Leadership, Culture, PSM Systems, Performance Indicators

INTRODUCTION

Recent major accidents in the Process Industries including those at Texas City US, Buncefield UK and in the Gulf of Mexico have highlighted the critical role played by senior managers and executives. Effective leadership is essential if companies are to develop a positive safety culture that remains constantly vigilant towards the risk of a major process safety incident. In the UK the HSE has made leadership a key priority for the high hazard industries and there is a cross-industry initiative to develop and deliver training focussed towards board members responsible for process safety performance.

This paper explores the leadership failings that contributed to recent major accidents, and the cost to both the company reputation and the individuals involved. Key principles are discussed that can help improve leadership in the major hazard industries. These include; attitudes and decisions of senior manager affecting the investment strategy and the safety culture of the organisation, reinforcing the importance of safety by personal example, thorough understanding of major accident hazards and key risk control systems, investigating process safety incident and near misses to find the underlying causes, developing world class safety management systems, and identifying weaknesses in these systems using targeted performance indicators.

The author bases this paper on the development of a training standard for 'Process Safety Leadership' involving a cross-industry 'expert panel'. Training of senior executives in compliance with this standard has been carried out from late 2011 and feedback from these courses and the key requirements for effective leadership will be discussed.

LEARNING FROM RECENT ACCIDENTS

Major accidents in the Process Industry causing multiple fatalities continue to occur worldwide at an unacceptable rate, causing massive costs to the companies involved and in some cases threatening their very existence. 'Industry defining' accidents at Flixborough UK, Seveso Italy, Bhopal India and Pasadena US in the 1970's and 1980's have caused tighter regulation of the industry and raised awareness of the key risk control systems needed to prevent such accidents. There has been worldwide convergence on the technical elements required for an effective Process Safety Management (PSM) system. However, recent accidents have increased awareness of the key role of senior managers and executives in ensuring these systems are effectively implemented and remain robust throughout the life of facility.

Investigations into the causes of the Texas City refinery explosion in 2005 that killed 15 people revealed a catalogue of failings in the PSM arrangements. This prompted a more fundamental review of the BP corporate safety culture across the refining operations in the US [Baker, 2007]. The panel made the following highly influential comments on BP management at the time of the accident. These are

relevant to leadership of process safety for all companies operating in the worldwide process industry.

- Companies should regularly and thoroughly evaluate their safety culture and performance of their process safety management systems.
- Preventing process accidents requires vigilance. People can forget to be afraid.
- BP has not provided effective process safety leadership and has not adequately established process safety as a core value.
- BP mistakenly interpreted improving personal injury rates as an indication of acceptable process safety performance.
- Process safety leadership appeared to have suffered as a result of high turnover of refinery plant managers.
- A good process safety culture requires a positive, trusting, and open environment.
- BP does not have a designated, high-ranking leader for process safety.
- The company did not always ensure that adequate resources were effectively allocated to support or sustain a high level of process safety performance.
- BP has not demonstrated that it has effectively held executive management accountable for process safety performance.
- The panel found instances of a lack of operating discipline, toleration of serious deviations from safe operating practices, and apparent complacency toward serious process safety risks.

A massive explosion at the Buncefield fuel storage facility in the UK occurred in 2005, causing extensive damage to off-site buildings but miraculously avoiding fatalities due to occurring early on a Sunday morning. Several layers of protection failed allowing a gasoline tank to overfill resulting in a vapour cloud explosion. There has been a thorough investigation by the regulators and a cross-industry group, resulting in a set of minimum standards for fuel storage facilities. Leadership failings were again highlighted as a major contributor to the Buncefield accident (HSE, 2001).

- Management systems relating to tank filling were both deficient and not properly followed, despite having been independently audited.
- The pressure on staff was made worse by a lack of engineering support from Head Office.
- A culture where keeping the process operating was the primary focus and process safety did not get the attention, resources or priority that it required.
- At the core of managing a major hazard business should be clear and positive process safety leadership with board-level involvement.
- What was set out in the Safety Report and the safety management systems did not reflect what actually went on at the site.
- The management Board did not effectively manage major hazards. It appeared more of a convenience for the financial management of the venture.

LEADERSHIP PRINCIPLES

Process safety culture is not a comfortable concept for engineers and managers to grasp, and yet a poor culture is something that most people working for an organisation can readily identify. The Baker report on Texas City highlighted the strong link between leadership and culture, supported by the quote [Schein, 2004], "*Leaders create cultures by what they systematically pay attention to*".

'Felt Leadership' is a concept promoted within DuPont, stressing the importance of leadership behaviours in creating an improved safety culture. For a leader this journey progresses from doing the right things, via being seen and influencing people, through to people really believing that you value these things. Felt leadership is about behaviours rather than just talking about safety, and includes principles such as; visibility to the organisation, behaving as you desire others to do, having continuous emphasis on safety expectations, showing a passion for zero incidents, investigating incidents to prevent recurrence, and setting personal goals as well as those for line managers.

The behaviours expected for effective process safety leadership in the chemical process industry have been summarised as follows (CIA, 2008) based on industry research. This includes the quote from Judith Hackitt, Chair of UK Health & Safety Executive (HSE), "*Process safety cannot be managed or led from the comfort of the boardroom*".

- Board champion for process safety ensuring discussion at all board meetings to review performance and set future priorities.
- Process safety policy communicated stressing the importance set by the board and role of people at all levels in delivering major hazard safety.
- Visibility of board level management, e.g. visiting control rooms, presentations on major hazard risks.
- Using effective Process Safety Performance Indicators (PSPI) to allow board level monitoring of leading and lagging indicators of process safety.
- Formalised process safety improvements plan in place for ensuring continuous improvement endorsed by the board.
- Outward looking company and board with cross industry approach to learning and sharing the lessons from incidents.

TRAINING STANDARDS

Following the learning from many incidents, improving process safety leadership has been set as a top priority by the UK HSE. A cross-industry group including representatives from the regulators, trade bodies, operating companies and consultancies has developed a training standard for 'Process Safety Leadership for Senior Executives'. This

aims to give executives a clear understanding of their responsibilities across an organisation and the methods used to deliver sustainable results through engagement of the workforce.

The standardised course has been offered through the National Skills Academy for the Process Industry (NSAPI) since late 2011, with many courses run by approved training organisations. Each delegate is required to develop a personal action plan on the course that is being followed up to confirm the action taken, and these have been used in this paper to look at a practical approach to improving process safety leadership.

The NSAPI has now developed a follow-up standard on 'Process Safety Management Foundations' that will be offered as open or in-house courses from mid 2012. This course is targeted towards site based staff and designed to provide a clear knowledge and understanding of the principles of process safety management across an organisation.

A PRACTICAL APPROACH FOR IMPROVEMENT

At this stage it should be clear that poor leadership has been implicated as an underlying cause of many serious accidents in the process industries. In addition there is a wealth of guidance on the principles that should be applied for effective leadership and significant pressure from the regulators for improvements in leadership to be treated as a high priority. The key questions for leaders who understand this message is what practically can be done and where they should focus their efforts in the short and medium term.

UNDERSTAND THE DIFFERENT APPROACH FOR 'PROCESS SAFETY'

It is clear that many executive boards have believed 'safety' to be under control based on falling injury rates, only to be surprised by a serious fire, explosion or toxic release event. They may excuse themselves having not received information from the organisation to indicate there were problems. However, the question is why has this information not been received, and are the board failing to make the organisation aware of process safety as a priority?

Figure 1 can be used to help explain to staff at all levels the differences between personal or occupational safety and process safety. Personal safety is related to relatively frequent low severity events generally associated with the behaviours of individuals. This has been successfully managed by improved management focus and behavioural safety initiatives, resulting in falling injury rates.

Process Safety relates to more serious events generally involving a loss of containment of hazardous substances or a release of energy. These events are rare and usually occur when several layers of protection have failed to prevent the escalation of an initial failure. The causes are varied and involve both immediate failings of equipment and people plus underlying or latent systems failures. Improving process safety performance requires effective organisational activity to maintain risk control systems and respond to any weaknesses identified.

The fact that a serious process safety incident has not occurred during the life of the facility is no guarantee that the event could not occur tomorrow. Management of process safety requires knowledge of the key layers of protection (risk control systems) and continuous monitoring of the effectiveness of these measures to detect any weaknesses in the defences. It should therefore be evident that routine monitoring by management needs to be focussed on different indicators for process safety than those established for personal safety.

IMPLEMENT BEST PRACTICE PSM SYSTEMS

The key elements of an effective PSM system are well defined in several publications and have generally converged between the US and UK over recent years. These elements have been identified as important following serious accidents in the process industry and have therefore been learned through bitter experience. For example, the Flixborough UK explosion in 1974 that killed 28 people was caused by the failure of a temporary pipe connection

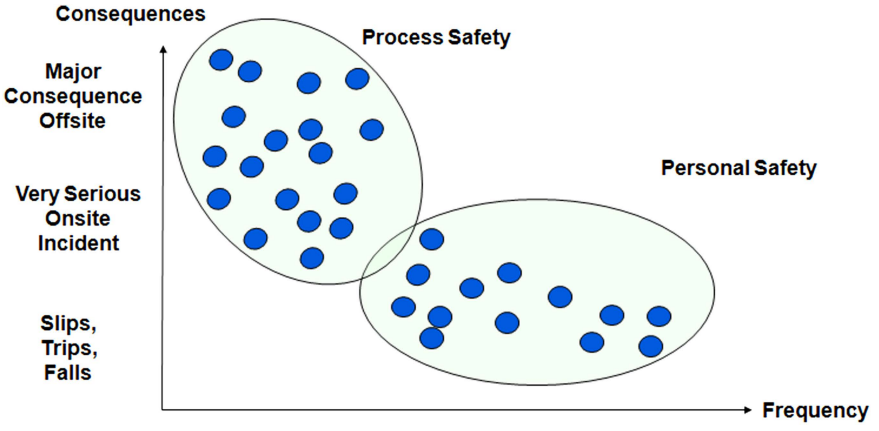

Figure 1. Comparison between personal and process safety

between two reactors. This lead to 'Management of Change' being a key element of a PSM system, with the essential requirement to carry out an assessment of the potential implications before any significant change is implemented.

Recent PSM systems (EI, 2010) have responded to the learning from accidents, including those at Texas City and Buncefield. The EI Process Safety Management Framework has 20 elements including the following 5 elements related to process safety leadership.

- Leadership commitment and responsibility, including process safety policy and performance targets, plus structure and resources to achieve them.
- Identification and compliance with legislation and industry standards, ensuring the requirements of applicable legislation are identified, understood and complied with.
- Employee selection, placement, and competency, and health assurance, to ensure that current and new personnel have the required competencies and are fit for work.
- Workforce involvement in order to align, involve and empower the whole workforce in the identification and management of process safety hazards.
- Communication with stakeholders, including identification of key stakeholders plus understanding and addressing their issues and concerns.

Figure 2 is based on the EI PSM framework and shows how these need to be integrated into continuous improvement across the lifecycle stages from design and construction to operation and maintenance. The risk assessment stage should be used to define the key requirements in the other elements related to specific process safety scenarios on the facility. Investigation of incidents, routine auditing and periodic process hazard reviews should then be used to identify weaknesses in these elements and changes needed to achieve continuous improvement in process safety.

The PSM systems operating within a company should follow basic good practice requirements but need to be tailored to reflect the organisation and specific process safety hazards. A large manufacturing site that produces and distributes chlorine will have procedures that are quite different to a small facility storing flammable liquids. An effective initiative for senior management is to carry out independent specialist reviews of their PSM procedures to identify and prioritise gaps and departures from what is considered relevant good practice. Where gaps are identified and new procedures required, it is important to implement procedures that meet the basic requirements and have been proven as practical within a similar organisation. For example, it is fairly easy to devise a 'Management of Change' procedure with all the required checks, but far more difficult to ensure this is used effectively by competent people to detect and assess all relevant changes.

UNDERSTAND PROCESS SAFETY RISKS

Any facility in the process industry will have a number of credible major accident hazard scenarios with the potential to cause serious harm to people or the environment. On a fuel storage facility such as Buncefield these would typically

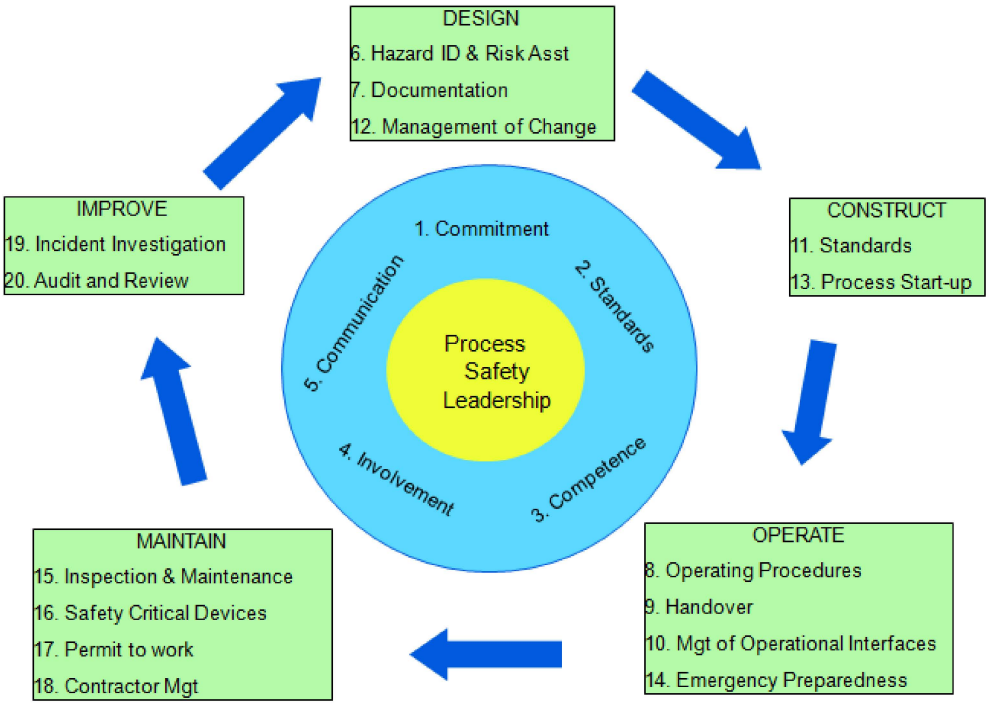

Figure 2. Lifecycle approach for PSM Systems

include overfilling storage tanks during fuel imports, hose failures during road tanker loading operations, and internal explosion or overpressure causing catastrophic rupture of a storage tank.

Major accident hazard scenarios are caused by known initiating events such as failure of hardware or control systems, or errors by operating or maintenance staff. There will be a number of layers of protection designed to prevent, control and mitigate these scenarios from escalating to a major accident. There should be sufficient controls to ensure that the risk has been reduced to an acceptable level.

Senior managers should have a good understanding of the main risk scenarios on the facilities they manage and be constantly vigilant to complacency towards these hazards from staff in the organisation. Information on scenarios should be described in the Safety Reports for regulated sites in the UK, or in similar documents such as periodic Process Hazard Reviews or HAZOP Revalidation studies. If this information is not available in an understandable format or is out of date, senior managers should initiate a thorough review of process safety hazards as a matter of priority. Without a thorough understanding of the hazards and risks on a facility it is unlikely that other PSM elements and risk control systems will be focussed towards the correct issues.

Figure 3 shows a typical risk matrix that has been populated with process safety scenarios for an entire facility. This shows that risk is a combination of event severity and likelihood, with high severity and likelihood events demanding action to reduce the risk to a lower and acceptable level. When reviewing such documents, senior managers should challenge their technical and operations staff to explain what action is being taken for events at the upper end of the risk profile, as shown in the red circle in Figure 3.

INVESTIGATE PROCESS SAFETY INCIDENTS

Reports on major accidents often reveal that several similar 'near misses' had occurred in the preceding years where the lessons were not effectively learned. At Texas City there had been several releases of hydrocarbons from the relief system during column start-up that had either not been thoroughly investigated or required improvements implemented.

Senior managers are often highly involved following a serious 'personal safety' accident involving hospitalisation or a lost time injury. The same level of interest is often lacking when a 'process safety' incident occurs, helping to reinforce the wrong message about the importance of process safety.

An example of a process safety 'near miss' (or 'near hit') would be operation on demand of the high level trip on a gasoline storage tank similar to those at Buncefield. Although no loss of containment has occurred on this occasion, the potential exists for a serious fire or explosion if the same event happens and the final protection system fails to operate. This was the case at Buncefield, where the ultimate high level trip system failed to operate due to the level switch being left in a disabled condition as a result of human error.

Senior Managers should ensure that following incidents on their facilities, the potential for more serious

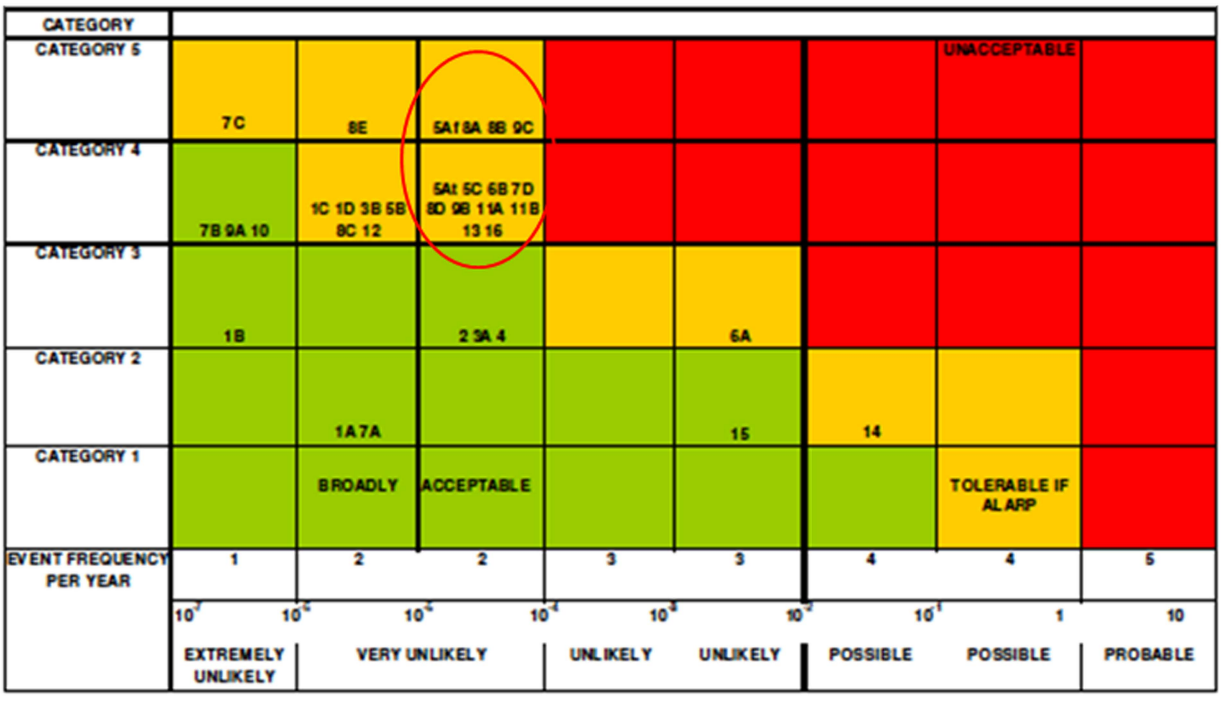

Figure 3. Typical risk matrix

consequences is correctly assessed, especially if a more serious incident was prevented only by human intervention. Thorough investigations should be initiated by a competent specialist for all process safety near misses, including those where critical protection systems have operated on demand. The investigation should assess both the immediate causes of the near miss plus any underlying or latent causes that have contributed. The aim should be to identify weaknesses in the PSM system that contributed to the incident, as correcting any deficiencies is likely to prevent a recurrence of this specific incident plus a range of other similar incidents.

Another key lesson from the Texas City accident was failures by senior management in providing resources to implement improvements. Whilst expenditure on essential safety improvements should be made readily available, senior managers should challenge their staff to demonstrate that spending is being targeted towards the areas of greatest risk. The objective is to ensure that the available resources targeted towards process safety improvement are achieving the optimum risk reduction using some form of simple cost-benefit analysis.

MONITOR PROCESS SAFETY PERFORMANCE

A key conclusion from the Texas City investigation [Baker, 2007] was that "*BP primarily used injury rates to measure process safety performance at its US refineries before the Texas City accident*". This reinforced a similar conclusion following incidents at the BP Grangemouth refinery in the UK in 2003 (HSE, 2003) and the need to develop key performance indicators for major hazards.

These reports have been influential in the development of Process Safety Performance Indicators (PSPI) within the process industry to allow management of process safety at all levels up to the board room. The objective is to have appropriate leading (predictive) and lagging (failure) indicators that are reported and assessed in a similar manner to injury rates for personal safety.

Figure 4 is a process safety pyramid based on published guidance (API, 2010), that suggests rare serious accidents at the top of the pyramid can be controlled by responding to more frequent and less severe incidents towards the base. The key requirements are to choose indicators that will provide enough data points to allow genuine monitoring and improvement, and ensure that these relate to the areas of greatest risk.

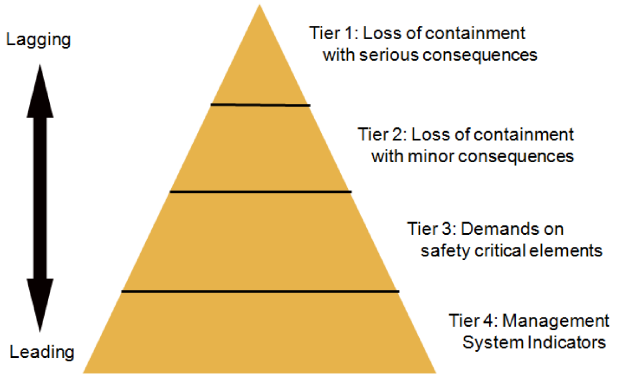

Figure 4. Process safety pyramid

Lagging indicators relate to reactive response to an event; for process safety these are generally related to loss of containment where harm to people or the environment has occurred or had the potential to occur. For example, a level 2 event is the loss of a significant quantity of gasoline from a storage tank into a bund/dyke where no ignition occurs. The same event where ignition occurs may result in a serious burn injury to an operator that would escalate the event to level 1. To ensure consistent reporting of these events it is useful to set some thresholds on types of harm for level 1 events, and minimum release quantities for level 2. For some sectors in the process industries these thresholds are being published aiming for consistent reporting across companies operating similar facilities.

Level 3 indicators generally relate to operation of an ultimate protection layer to prevent a loss of containment, for example a high level trip on a storage tank. It can be argued whether these are leading or lagging indicators, but the important point is to first be aware of the critical protection layers on a facility, then ensure a strong response should any of these systems operate in anger. It is a common finding on process hazard reviews to find acceptance of frequent process trips, with a view that the system is operating as designed.

The real challenge when setting up an effective PSPI system is to identify appropriate and risk targeted level 4 leading indicators. These should come from the source of frequent 'free lessons' that indicate weaknesses within the risk control systems, including people, plant and procedures. Many companies have been pressurised by the regulators to implement a PSPI system including leading indicators. It is convenient to start reporting existing measures related to safety, for example whether pressure vessels are being given statutory inspections within the allowed period. Using this measure as a PSPI should be challenged by senior managers who should ask whether there is any history of late inspections and whether these have increased the risk of a process safety incident.

Senior managers should consider an independent specialist review of their PSPI system focussing on leading indicators. This should be based on a review of the major accident hazard scenarios on the facility and the history of process safety incidents and near misses. The review should be used to identify the critical risk control systems that have shown weaknesses, and from these suitable leading indicators should be selected and implemented. An important step is to test whether these indicators are SMART, defined as follows.

- Sufficient data to trend improvement
- Measurement can be done efficiently
- Accurate enough to be accepted
- Reliable means of collection
- Targeted to the risk control systems of greatest concern.

CARRY OUT SITE VISITS

Using the principle of 'felt leadership' it is important that the behaviours of senior managers are seen and that people believe they are serious about process safety. Having set policies and declared the importance of process safety to the organisation, senior managers should get out of their offices and board rooms and 'walk the talk' on process safety. They may feel uncomfortable in dealing with the technical aspects of process safety with engineering and operations staff. The following questions could be asked to challenge staff, for instance when visiting a supervisors' office or control room on a major hazard facility.

- What was the last serious process safety incident and what has been done to prevent recurrence?
- What measures can you show me that process safety is being managed properly?
- What safety systems are out of service or overridden?
- What safety-critical equipment inspections or proof tests are overdue?
- What equipment is running outside of design limits or inspection recommendations?
- What is the biggest process safety risk on site. . .can you show me why the process is safe?
- What independent assessment have you had to show you're managing process safety properly?
- Show me how you have learned from a recent major incident outside of the company?
- Show me how you manage process safety competence?
- How many safety systems have operated in anger recently? Why and what have you done about it?
- Have you had any process safety incidents that have been prevented from being worse by human intervention?
- What process safety experience and expertise do you have on site?

CONCLUSIONS

Companies need to be constantly vigilant to the risk of a major accident on their facilities, which could result in massive costs and threaten their future existence. Not having had such an accident is no guarantee that it could not happen tomorrow, so it is essential to start monitoring process safety performance and responding to warning signs. The policies, systems and measurements for 'Process Safety' should raise awareness to at least the level established for 'Personal Safety', remembering that both aspects of the safety challenge are important.

There has been greater awareness of the responsibility of senior executives for process safety following investigations into recent accidents. Key leadership principles have been outlined in this paper and should be critically reviewed by senior managers to check that they are doing all that can be reasonably expected. This should be done as a matter of urgency, and before the soul searching that would follow a serious accident, with explanations sought from the regulators, the public, and the relatives of those killed or seriously injured.

This paper has outlined a number of key steps that could be taken by senior managers to initiate improvements in process safety performance. A range of steps are required with the overall approach dependent on the relative maturity of the organisation towards process safety. The author believes that ensuring a strong response to process safety incidents and near misses is the most important step that can be taken by a senior manager. These should be thoroughly investigated to find the weaknesses in the overall process safety risk control systems and the learning used to implement focussed improvements to prevent the recurrence of this or similar incidents.

REFERENCES

1. Baker, J., 2007, The report of the BP U.S. refineries independent safety review panel.
2. HSE, 2011, Buncefield: Why did it happen? The underlying causes of the explosion and fire at the Buncefield oil storage depot, Hemel Hempstead, Hertfordshire on 11 December 2005, HSE Books.
3. HSE, 2003, Major Incident Investigation Report, BP Grangemouth Scotland, 29th May – 10th June 2000, 18th August 2003, HMSO.
4. Schein, E.H., 2004, Organizational Culture and Leadership, John Wiley & Sons.
5. CIA, 2008, Best Practice Guide: Process Safety Leadership in the chemicals industry, Chemical Industries Association, London.
6. EI, 2010, High level framework for process safety management, 1st edition, Dec 2010, The Energy Institute, London.
7. API, 2010, Process Safety Performance Indicators for the Refining and Petrochemical Industries, Recommended Practice 754, 1st edition, April 2010, American Petroleum Institute.