

ORGANISATIONAL AND CULTURAL CAUSES OF ACCIDENTS – A PILOT STUDY

Marc McBride*, Richard Taylor† and Glenn Sibbick*

*Centrica plc, Millstream, Maidenhead Road, Windsor, Berkshire SL4 5GD, UK

†University of Bristol, Department of Civil Engineering, Safety Systems Research Centre, Queen's Building – University Walk, Bristol BS8 1TR, UK

A team from the Safety Systems Research Centre (SSRC) at the University of Bristol has recently completed a major study of the organisational and cultural precursors leading to ten major events (more recently extended to two others) which have occurred across a range of industries. The work was funded by the Health and Safety Executive (Nuclear Installations Inspectorate - now the Office for Nuclear Regulation) and, initially, by British Nuclear Fuels Limited.

One of the main conclusions of the study was that the precursors to the events were strikingly similar whatever the industry and the nature of the process being managed. These precursors have been grouped under seven general headings:

- Leadership;
- Operational attitudes and behaviours;
- Commercial pressures/business environment;
- Learning from events;
- Competence;
- Risk assessment and management; and
- Oversight, scrutiny and audit.

For each of these areas, the relevant findings were analysed and a series of statements of good practice formulated which, it was argued, would have provided defences against the events. From each of these statements a series of more penetrating questions was developed which attempt to evaluate whether an organisation has embedded systems and behaviours which are likely to achieve the good practices and to provide an understanding of the 'real situation' in the organisation.

This paper describes a short pilot study in which the statements and associated questions from the Bristol University research were tested in an industrial context, in this case a large integrated energy company (Centrica plc). The statements were tested at both a corporate level (Phase 1) and within an operational business (Phase 2).

A previous HAZARDS conference paper described the outcome of Phase 1 of the study. This paper covers Phase 2 and describes the learning both for the company (ie potential improvements to organisational resilience) and for the researchers in terms of the usefulness of the statements and questions as a tool for assessing vulnerability.

1. INTRODUCTION

There is increasing realisation that major technological accidents and significant near misses, such as the space shuttle disasters, incidents in the oil and gas industry and railway accidents have strikingly similar organisational and cultural precursors. It follows therefore that the lessons from such accidents can be applied widely, beyond the particular industry sector in which they occurred.

The basis for this paper is research undertaken by the Safety Systems Research Centre (SSRC) at Bristol University into the organisational and cultural causes of ten accidents and significant events across a range of industrial sectors (van Wijk, et al., 2008). The findings from this research have been applied in a pilot study undertaken by Centrica plc in conjunction with Professor Richard Taylor, the research team lead.

McBride et al. (2011) described the first phase of the pilot study, which was to apply the statements of good

practice developed by the researchers at a corporate level within Centrica. This gave useful pointers to the company in terms of areas of improvement and/or required additional emphasis within corporate safety expectations.

This paper describes the second phase of the pilot study which took one aspect of the research (safety leadership) and tested the statements of good practice and underlying questions within an operational business (Centrica Storage). Leadership was chosen as the topic because it is fundamental and underpins many of the issues highlighted in the seven identified areas. It is also one in which Centrica has a particular interest and contribution to make.

Section 2 provides more detail on the output of Bristol University's research, including the statements of good practice (or expectations) and associated questions on leadership. Section 3 then summarises the methodology for the pilot study. Section 4 describes the outcome of the study, both from the researchers' and Centrica's perspective. Finally,

Section 5 gives the overall conclusion on both phases of the pilot study and the intended future direction of research.

2. FINDINGS AND EXPECTATIONS ON LEADERSHIP FROM THE BRISTOL UNIVERSITY RESEARCH

2.1 FINDINGS ON LEADERSHIP FROM THE TEN EVENTS STUDIED

Leadership failings are apparent in the investigation reports of all of the events studied. The following passages, from two of the reports, illustrate Bristol University's findings on this topic:

Columbia Shuttle Accident, 2003

(Break-up of space shuttle on re-entry into the earth's atmosphere following damage to the thermal protection system as a result of a foam strike during launch)

"Program managers created huge barriers against dissenting opinions by stating preconceived conclusions based on subjective knowledge and experience, rather than on solid data. Managers demonstrated little concern for mission safety. Organizations with strong safety cultures generally acknowledge that a leader's best response to unanimous consent is to play devil's advocate and encourage an exhaustive debate. Mission Management Team leaders failed to seek out such minority opinions. Imagine the difference if any Shuttle manager had simply asked, 'Prove to me that Columbia has not been harmed?'" (CAIB, 2003)

THORP Radioactive Leak, 2005

(Leak of 83 m³ of highly-active liquor inside a containment cell at the Thermal Oxide Reprocessing Plant, Sellafield, which went unnoticed for 8 months)

"The fact that there were some long-standing failures in some key safety arrangements and uncertainties in roles and responsibilities, raises questions about the effectiveness of the company's arrangements for monitoring, audit and review. There need to be effective arrangements to provide assurance that those controls to ensure safety which are intended to be in place actually are in place, and are working effectively. Senior managers cannot rely on the absence of incidents as an indicator that everything is as it should be or as they would wish. This reinforces the importance of a questioning attitude and a challenging culture." (HSE, 2007)

2.2 EXPECTATIONS ON LEADERSHIP DERIVED FROM THE RESEARCH

Based on the findings from the ten events studied, the team at Bristol University developed statements of good practice in process safety leadership. The key points are summarised below:

1. There is clarity about values and commitment, ie process safety is a high priority and this is presented in an explicit policy.
2. Expectations on attitudes and behaviours are clearly communicated, eg on procedural compliance, with a conservative/questioning approach to process safety, and workforce involvement.
3. Policies, standards etc. cover key issues and provide clear expectations on businesses.
4. Assurance is obtained on the translation of these expectations into business requirements, and their effectiveness is reviewed.
5. The need for visible and demonstrable leadership, ie actions to match words, is evident through leadership behaviours.
6. Evidence of engagement with reality, ie leaders having a good knowledge of the real issues, not a 'good news' culture.
7. Leadership competence in process safety risks is ensured and maintained among top decision-makers.
8. The requirement to ensure competence in front line supervisors and in all process safety-related operations is explicit.
9. Clear accountabilities are assigned with attention to interfaces and coordination, including contractors.
10. Leaders understand their key role as the 'controlling mind' or 'intelligent customer' for the organisation.
11. There is effective monitoring of performance against targets (with a range of proactive process safety key performance indicators) and within a defined scrutiny/oversight process with independent input.
12. There is clear evidence of actions, reflecting the need to detect and act on deteriorating performance and organisational drift. These are monitored and tracked.
13. There is a clear requirement for all businesses to operate within a systematic safety management system based on good practice.
14. Emphasis is placed on the need to ensure effective communication on process safety issues within a cascaded, managed framework which encourages feedback.
15. There is a clear requirement for a reporting culture based on a 'just' process for event reporting and for all events to be investigated to the extent warranted by their significance.
16. Business leaders have a good understanding of external organisational accidents and the implications for their business.
17. Business decision-making shows an appreciation of key process safety risks and integrates these with other business goals in a way which ensures that process safety is a priority.
18. Commitment to continuous improvement is maintained as a priority and sustained with adequate resources.
19. Business incentives do not have a potential detrimental effect on process safety.

20. Leaders have a systematic process to evaluate and monitor the impact of organisational change and assess the implications of business pressures on process safety.

In addition to the statements of good practice, the research team also developed a question set to test the reality of whether such conditions are present within an organisation. This comprised 60 questions in total, examples of which are given below, linked to the relevant expectations.

Leadership competence:

- How do you ensure that you and your team (including non-technical members) have sufficient knowledge and understanding of process safety issues to support you in your role and in decision-making?
- When did you last receive training relevant to process safety issues and has it been refreshed? What were the main points of learning which you took away?
- How do you obtain specialist advice on process safety issues and how do you ensure that this is independent and not influenced by business pressures?
- When was the last time you sought the views of your independent safety advisor and when did he/she last raise an issue which had an impact on a business decision relating to process safety? What happened as a result?
- What measures do you take to ensure that the advice you receive remains competent, that sufficient resource is available to such specialists and that independent process safety expertise and knowledge (corporate memory) is being retained?

Priorities and risk management:

- How do you make decisions about priority areas for improvement and the commitment of resources in process safety? Is this part of a systematic process?
- How do you ensure that, when decisions are made at senior level, the process safety risk implications have been fully considered with a questioning and conservative approach, taking account of areas of uncertainty?
- Can you cite any recent examples of where a business decision has been modified as a result of consideration of process safety concerns?
- When you or the leadership team have identified a risk requiring priority action or approved a recommendation for such action, how do you satisfy yourselves that sufficient resource is available and that the matter has then been dealt with in an acceptable and timely way and had the desired effect? Can you give examples?

3. THE PILOT STUDY

The second phase of the pilot study was undertaken in conjunction with Centrica Storage, the UK's largest gas storage business, operating two offshore installations and an onshore gas processing terminal. The pilot study builds on previous and ongoing dialogue between Bristol University and Centrica Storage on the common causes of industrial

accidents and strategies to prevent their recurrence. Through its 'collective mindfulness' programme and involvement in developing the process of cross-sector peer review (Sellers et al, 2009), Centrica Storage were able to bring valuable operational experience to the study.

The intention of the second phase of the pilot study was to further develop the question set (Section 2) by carrying out a trial of its use in a real setting with senior managers responding to the questions and providing feedback. In addition to improving and rationalising the question set, the process was of use to Centrica Storage in identifying where there might be areas of vulnerability and, in particular, where greatest benefit might be obtained in further work to strengthen capability across the organisation.

For logistical reasons, the second phase of the pilot study was undertaken in two parts. The first part comprised a discussion with the Centrica Storage Terminal Manager focussing on his area of management responsibility. Other senior managers were present who contributed to the discussion at appropriate points. This was valuable in enabling feedback to be obtained from both the interviewee and other senior colleagues, in relation to the value of each area of questioning and the specific questions. In the second session, the remaining questions were reviewed one-to-one with a more senior member of the management team who has wide experience of similar management roles and of the relevant plant.

4. OUTCOME OF THE PILOT STUDY

4.1 VALIDITY AND APPLICATION OF THE QUESTION SET

In the opinion of the interviewees, the majority of the questions were demanding, probed the reality of the leadership approach and thus could lead to a strengthening of current approaches to leadership at various levels. With some further adjustment and development, the questions provide a good basis for development of a more detailed vulnerability tool.

The pilot study enabled the question set on leadership issues to be refined and strengthened on the basis of the feedback from those at the receiving end. It also provided some useful pointers as to how it might be more generally improved in structure and use. Specifically, one of the improvements to be taken forward is to tailor the question set to enable it to be applied to leadership roles at different levels in an organisation, from frontline managers and supervisors, through site leadership to corporate executives and directors.

4.2 LEARNING FOR CENTRICA STORAGE

On the part of Centrica Storage, the pilot study identified both good practices and potential areas of improvement, examples of which are discussed in the following paragraphs.

Among the good practices identified was Centrica Storage's approach to communications. Breakdown of

communications is often cited as a contributory factor in major accidents, eg the poor vertical communication at the Texas City refinery which contributed to BP's inability to identify and clearly articulate priorities around process safety and operational requirements (CSB, 2007). Features of Centrica Storage's approach include high visibility of site leadership (eg at shutdowns), strong and positive interaction with safety representatives, and high levels of contact (formal and informal) between leaders and the rest of the workforce.

Another good practice identified was Centrica Storage's use of a strong suite of pro-active key performance indicators for process safety, which includes such measures as overdue actions, alarm rates, pressure systems inspections, safety-critical maintenance backlog, outstanding management of change requests and monitored (minor) leaks. Centrica Storage is enhancing its process safety performance indicators as part of its 'high reliability organisation' project, based on the approach of Scottish Power (HSE, 2011). This will initially enhance the suite of manually-generated performance indicators then develop an automated dashboard to provide near real-time information to managers to facilitate necessary control action.

In terms of potential areas of improvement, the study identified ongoing assurance of leadership competence in process safety as one such opportunity. This is reflective of current trends within the major hazard industries to enhance the knowledge of senior managers and leaders in process safety (eg NSAPI, 2012) as well as renewed emphasis by the regulator (HSE, 2012). Centrica Storage has developed awareness of process safety through various initiatives including its collective mindfulness programme (based on the common learning from a number of high profile accidents), half-day process safety awareness training as well as a re-enactment of the Texas City accident. In 2012 this is being enhanced through 2-day workshops at GL Noble Denton's specialist Spadeadam facility, which provides the opportunity to mix formal training with large scale demonstrations of fire and explosions. Each workshop is facilitated by a member of the senior leadership team (including those in non-operational/technical roles) and includes a talk by a survivor of the Piper Alpha disaster to enhance the theory and concepts with first-hand experience of a major accident. Centrica Storage's training programme encompasses the entire onshore and offshore workforce (approximately 150 personnel).

Another potential area of improvement noted was in relation to action follow-up, ie to ensure that learning (eg from audits or incident investigations) translates to action which is then closed-out and checked for effectiveness. A frustrating aspect of many past incidents is that the organisations involved had recognised the need to improve but had failed to act effectively and quickly enough to close the performance gap. An example of this was the Longford gas plant explosion (Longford Royal Commission, 1999) in which a heat exchanger failed catastrophically at low temperature, leading to fire which killed two workers. One of the contributory causes identified by the Royal Commis-

sion was the failure to identify and adequately control the hazard of low temperature embrittlement. Esso had budgeted to carry out a Hazard and Operability (HAZOP) study of the plant in each of the three years prior to the incident occurring, but had deferred it for various reasons, eg that it would have taken a long time to complete or picked up too many little items.

5. CONCLUSIONS AND NEXT STEPS IN PROPOSED RESEARCH

The pilot study described in this paper has provided a useful first test of the statements and question sets arising from Bristol University research on organisational vulnerability to major accidents. For the researchers it has provided an opportunity to refine the questions sets, and their application, to give a stiffer test of the whether 'reality meets expectation' in organisations managing major hazards. On the part of Centrica, it has provided useful pointers to where organisational resilience can be strengthened both at a corporate and operational level.

The pilot study is a useful step on the way towards new, multi-disciplinary research currently proposed by Bristol University (working in conjunction with other universities and organisations in a variety of high hazard sectors) to understand the organisational and cultural causes of major accidents and apply this to minimising 'organisational accidents'. This proposed research will further test the questions sets and then develop them into a practical tool which would allow the identified organisational and cultural precursors to be used to assess vulnerability, and to facilitate sharing of good practice between the industry sectors represented in the research programme. The proposed approach may be seen as complementary to the analyses which are widely undertaken to assess engineering vulnerabilities.

From the research carried out thus far, repeating patterns of system failure have also been identified. Such patterns have previously been identified in other research (Leveson, 2012), but the use of a wide range of accident investigations allows a more comprehensive view to be taken. The complex, interactive and dynamic processes occurring in the development of the accident precursors will be modelled using a variety of techniques and this will allow important factors to be identified and understood – often missed when analysis is carried out using linear, static causation chains of engineering, systems and human failures. The analysis will also incorporate the psychological factors at play in individual and group decision-making. This would make it possible, for example, to identify where common mis-alignments occur between organisational intentions and the attitudes and behaviours of those whose input is required to deliver safe outcomes.

The proposed research should allow 'What if?' scenarios to be explored and sensitivity analysis to be carried out – akin to a management flight simulator – and the development of socio-technical condition monitoring tools which will allow industry to monitor the build up of incubating precursors to organisational failures.

REFERENCES

- CAIB 2003, Columbia Accident Investigation Board, Report Volumes 1–6, Printing and Distribution by the National Aeronautics and Space Administration and the Government Printing Office, Washington DC.
- CSB 2007, US Chemical Safety and Hazards Investigation Board, Investigation Report: Refinery Explosion and Fire, Report No. 2005-04-I-TX.
- HSE 2007, Report of the investigation into the leak of dissolver product liquor at the Thermal Oxide Reprocessing Plant (THORP), Sellafield, notified to HSE on 20 April 2005, Health and Safety Executive.
- HSE 2011, Case study: Scottish Power – Power generation company gets to grips with process safety, Health and Safety Executive.
- HSE 2012, COMAH Competent Authority – Inspection of Competence Management
- Leveson N. G. 2012, Engineering a safer world: systems thinking applied to safety, MIT Press.
- Longford Royal Commission 1999, The Esso Longford Gas Plant Accident: Report of the Longford Royal Commission, Department of Premier and Cabinet, Act Number 42/99, Parliament of Victoria, Melbourne, Australia.
- McBride M., Taylor R. and Marsh C. 2011, Organisational and cultural causes of accidents – a pilot study, IChemE HAZARDS XXII conference, Liverpool, UK.
- NSAPI 2012, The UK strategy for skills in process safety management 2012-2014, National Skills Academy Process Industries.
- Sellers G., Mason D. and Hemmings K. 2009, Accelerating learning through cross-sector peer reviews, IChemE HAZARDS XXI conference, Manchester, UK.
- Systems at COMAH Establishments (Operational Delivery Guide), Health and Safety Executive.
- van Wijk L., Taylor, R. and May, J. 2008, Cultural and Organisational Factors Leading to Major Events, International Topical Meeting on Safety of Nuclear Installations, Dubrovnic, Croatia.