ORGANISATIONAL AND CULTURAL CAUSES OF ACCIDENTS – A PILOT STUDY

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

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 were developed, and are currently being trialled, 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 – undertaken in two phases – 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, or Group, level and within an operational business. The findings from Phase 1 of the study are presented in terms of the learning for the company, i.e. potential improvements to organisational resilience.

INTRODUCTION

There is increasing realisation that major technological accidents, such as the space shuttle disasters, incidents in the oil and gas industry and railway accidents have strikingly similar organisational and cultural precursors (Hopkins, 2009). 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 the pilot study described in this paper is research undertaken by the Safety Systems Research Centre (SSRC) at the University of Bristol into the organisational and cultural precursors to ten accidents and significant events across a range of industrial sectors (van Wijk, et al., 2008). Table 1 lists the events studied.

The research study, led by Professor Richard Taylor, revealed similar organisational and cultural precursors for the ten events studied. The relevant findings taken from analysis of the investigation reports were assembled under the seven headings, above. For each of these areas, the relevant findings were analysed and a series of statements of good practice were formulated which, it was argued, would have provided defences against the events. These statements have the strength of being based on the learning from the organisational and cultural issues which led to the events studied and provide a suitable starting point for analysing the completeness of the defences in any existing organisational approach to achieving high levels of process safety. The results may also assist organisations in strengthening their approach to event investigation in order to extract the maximum learning in relation to cultural and organisational issues – for example from the investigation of 'near-hits'.

From each of the statements, reflecting the findings, fuller expectations of good practice were developed, and these in turn have been used to draft a series of more penetrating questions 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.

Table 1. The ten events studied in the Bristol University research

Date	Event	Reference
Sep 1994	Port of Ramsgate walkway collapse, UK	HSE (2000a)
Oct 1994	Heathrow Express NATM tunnel collapse during construction, UK	HSE (2000b)
Sep 1998	Longford gas plant explosion, Australia	Longford Royal Commission (1999), Hopkins (2000)
Sep 1999	Tokai-mura criticality accident, Japan	IAEA (1999)
Oct 2000	Hatfield railway accident, UK	ORR (2006)
Feb 2002	Davis-Besse pressure vessel corrosion event, US	USNRC (2002)
Feb 2003	Loss of the Columbia Shuttle, US	CAIB (2003)
Apr 2003	Paks Nuclear Plant fuel cleaning event, Hungary	IAEA (2003), HAEA (2003)
Mar 2005	Texas City oil refinery explosion, US	BP (2005), CSB (2007), Baker (2007)
Apr 2005	Loss of containment at the THORP Sellafield reprocessing plant, UK	HSE (2005)

THE FINDINGS FROM THE TEN EVENTS

Under each of the seven general headings (leadership, competence etc.), sets of twelve expectations were developed as potential generic 'defences'. In this section we bring out some of the key issues which were included in these expectations.

LEADERSHIP

Weak or ineffective leadership was considered to be the most fundamental issue leading to most of the events analysed. Examples of findings in this area are as follows:

- There is clarity about values and commitment, i.e. process safety as a high priority, in an explicit policy.
- Expectations on attitudes and behaviours are clearly communicated, e.g. on procedural compliance, on a conservative/questioning approach to process safety, and workforce involvement.
- Policies, standards etc. cover key issues and provide clear expectations on businesses.
- Assurance is obtained on the translation of these expectations into business requirements, and their effectiveness is reviewed.
- The need for visible and demonstrable leadership, i.e. actions to match words, is evident through leadership behaviours.
- Evidence of engagement with reality, i.e. leaders having a good knowledge of the real issues, not a 'good news' culture.
- Leadership competence in process safety risks is ensured and maintained among top decision-makers.
- The requirement to ensure competence in front line supervisors and in all process safety-related operations is explicit.
- Clear accountabilities are assigned with attention to interfaces and coordination, including contractors.
- Leaders understand their key role as the 'controlling mind' or 'intelligent customer' for the organisation.

OPERATIONAL ATTITUDES AND BEHAVIOURS

Analysis of the events provided many examples of issues relating to operational attitudes and behaviours. Examples of findings in this area are as follows:

- The workforce demonstrably understands leadership expectations on safety culture and the priority of process safety.
- The effectiveness of supervision/front line leadership is given high priority.
- Consistent questioning attitude/challenge is encouraged and demonstrated.
- Management support exists for 'safety first' decisions with managers prepared to stop work if necessary.
- Conservative decision-making is encouraged and demonstrated in the light of uncertainty or incomplete knowledge.
- Processes are established – and their use encouraged – to review and question safety during a job or process, e.g. through time-outs or point-of-work assessments.
- The requirement for procedural compliance is clear – no 'workarounds' are acceptable and poor procedures are reported and improved.
- Procedures are up-to-date and relevant and developed with workforce involvement.
- The workforce understands the risks being controlled by procedures and why key steps achieve control.
- The workforce – including contractors – is trained in the importance of safety culture and is given the opportunity to give feedback on strengths and weaknesses in the workplace.

COMMERCIAL PRESSURES/BUSINESS ENVIRONMENT

Nearly all of the events studied arose against a background of significant commercial and/or operational pressure. In any organisation there is always a balance to be struck between the pressures of production/delivery

and the achievement of acceptable levels of safety performance. It is when the balance leans towards an emphasis on achieving commercial results at the expense of safety that danger arises. Examples of findings in this area are as follows:

- Business developments with potential for conflict with good process safety are recognised, challenged and conservatively managed.
- Sufficient resources – human and financial – are provided at all times against defined baselines.
- Organisational changes potentially affecting process safety are recognised, challenged and managed within a defined process. It is important however that the process generates a degree of challenge and does not simply rubber stamp decisions that have already been taken for business reasons. It is also important that the process includes any transition phase.
- Material conditions on plant are managed to defined standards – business pressures are not allowed to lead to a decline in safety-related provisions.
- Mergers and acquisitions are managed to recognise and address impacts on process safety with clarity about expectations, priorities and the safety management system.
- Improvement and maintenance programmes are prioritised and sustained. Priority actions are tracked to completion and are not deferred without analysis of process safety implications.
- Incentives and rewards which could adversely affect process safety – either directly or indirectly – are not used.
- In outsourcing and use of contractors, an intelligent customer role is maintained with clarity about control, interfaces and accountabilities.
- Contractual arrangements recognise process safety management and control issues.
- There is recognition of issues relating to 'orphan'[1] plant and processes during business evolution.

LEARNING

For most of the events studied there had been previous events from which there was suitable learning available. If this had been acted upon, the event would not have occurred. Examples of findings in this area are as follows:

- Reporting of events and near-hits is encouraged and effective within a simple-to-use and 'just' process.
- All events are investigated to the extent warranted by their significance, actions prioritised, followed through and effectiveness monitored.
- The effectiveness of reporting and investigation leads to fewer repeat events – this is monitored.
- Investigations elicit root causes, including organisational and cultural issues.
- Results are shared and reviewed with an open mind to maximise learning.
- Sharing of learning and good practices takes place widely, internally and externally.
- The role of the workforce – including contractors – in identifying and driving improvement is recognised and encouraged.
- Both team and peer review is encouraged with provision of sufficient resources. Support and follow-up leads to visible improvement in priority areas.
- Sharing of good practices is encouraged between teams – including contractors – with positive action to breakdown silos.
- Learning from events is retained in the corporate memory – particularly following organisational change – and is incorporated into training.

COMPETENCE

Shortcomings in competence were present in most of the events studied. Examples of findings in this area are as follows:

- Adequate provision of resources is available for training in a variety of forms, including support and follow-up to establish effectiveness.
- Baseline levels of competence and resources are identified to ensure a capable organisation and proactively to identify areas of 'thin' competence.
- Competencies in process safety are systematically defined for all relevant posts, including those of leaders.
- Appropriate training in process safety issues is carried out on a systematic basis for all staff, including leaders, and outcomes reviewed.
- Training and capability needs are systematically identified and reviewed across the organisation, including induction, refresher training etc.
- Competence and performance in relation to process safety is systematically and regularly reviewed by line managers on a one-to-one basis, as with financial matters.
- Reviews are carried out to ensure that competence is maintained during organisational change, including incremental change.
- Process safety competence requirements are assessed in making key appointments, including leadership teams.
- Training is provided to deal with abnormal events, and to raise awareness of the safety culture and organisational issues which lead to them.
- Succession planning is employed to minimise the impact of potential loss of key process staff and rotation in leadership roles is reviewed for its impact on process safety.

RISK ASSESSMENT AND MANAGEMENT

This area has again been highlighted by almost all of the events studied and includes a wide range of issues from the strategic to the specialist, through to the assessment

[1]Plant which is peripheral, not in the mainstream of the organisation's business.

and management of risks in day-to-day operations. Examples of findings in this area are as follows:

- Processes are defined and reviewed – at all levels – to ensure that process safety risks are identified, assessed and managed on a graded or prioritised basis.
- Leaders and managers have a clear understanding of the process safety risks that they control.
- The effectiveness of follow-up and completion of actions resulting from risk assessments is reviewed.
- Measures to assess and control engineering risks, e.g. HAZOP studies, are available and used effectively as input to safety cases and improvement priorities.
- Safety cases, risk assessments, key documents and records are kept up-to-date and this is reflected in operational requirements.
- Operators have a good understanding of safety cases and related control measures – the safety 'envelope' – and understand their relevance to operations.
- Process safety requirements are controlled and monitored and not routinely waived.
- Operations do not proceed in the presence of alarms and plant failures unless process safety implications have been adequately assessed. Issues relating to operator overload are recognised in this context.
- Independent competent advice and support is available to operators and they are clear when support is required.
- Critical re-appraisal of process safety risks takes place to avoid the normalisation of risks and organisational 'drift'[2] or loss of focus.

OVERSIGHT, SCRUTINY AND AUDIT

When failures occur in systems and/or as a result of a weak organisational culture, this can be put right before a major failure occurs by oversight systems designed to alert different layers of the organisation to the deficiencies. Failures in oversight were, perhaps unsurprisingly, a common feature of all of the events studied. Examples of findings in this area are as follows:

- There exists a 'layered' process, independent and informed by appropriate evidence at each level of the organisation.
- Oversight is given regular and in-depth attention by lead teams at all levels and draws on support from advisors who are challenging and independent.
- The process takes account of a range of inputs including key performance indicators, events, other audits and reviews etc. to form an overall judgement on process safety performance.
- There is adequate resource, frequency is defined, and follow-up on actions is integrated and tracked to completion. The effectiveness of oversight processes is reviewed.
- Audits go beyond 'paper' systems – they assess the response to the paper system.
- Leaders, including those in non-technical roles, have sufficient understanding to assess the risks but competent specialist and independent process safety advice is available to inform and challenge at all levels.
- Oversight/scrutiny takes account of safety culture and organisational issues. Workforce perceptions are used to inform judgements.
- Awareness is maintained about the danger of organisational drift, complacency and mindsets and the oversight process seeks to identify the existence of these.
- Suitable leading and lagging metrics for process safety are measured and reviewed.
- Information from the layers of the oversight processes is available to decision makers in a form that allows them to make informed judgements, i.e. it is not 'rolled up' so that operational reality is lost.

[2]A high performing plant or part of the organisation in which performance gradually deteriorates and standards fall, while leaders and regulators continue to act as though the plant has retained its previous high standards.

THE PILOT STUDY

The pilot study, which is the subject of this paper, comprised application of statements formed from the above findings, and their supporting questions sets, to requirements and expectations on process safety within Centrica plc. Centrica is a large integrated energy company with major hazard activities in the UK and overseas. The pilot study started by looking at the Group-level expectations (Phase 1) and then to how these evolve into requirements and practices in an operating business unit (Phase 2). The specific business unit chosen for Phase 2 was the gas storage operation within Centrica's UK operations (Centrica Storage Ltd), comprising onshore gas processing terminals and offshore installations.

The intent behind the study is to provide learning for both the company, in terms of potential improvements to organisational resilience, and for the Bristol University researchers, in terms of the usefulness of the statements and questions as a tool for assessing vulnerability.

This paper reports the results of Phase 1 of the pilot study.

FINDINGS FROM THE PILOT STUDY

Overall, there were many useful findings from comparison of the research statements against Centrica's Group-level expectations on process safety. Many of these relate to the specifics of how Centrica has expressed its requirements within policies and standards, and are not covered here. However a number of the findings are of more generic value and wider industry interest. Five such findings are discussed below. These relate to aspects of process safety in which Centrica has identified potential opportunities for improvement or, at least, increased emphasis within its corporate documentation and approach to management of major hazards.

THE ROLE OF FRONTLINE SUPERVISION

An important theme from several of the events studied in the Bristol University research was the need for competent

Table 2. Key strengths and challenges in supervision in the UK offshore oil and gas industry (from NSOAF, 2008)

Key strengths	Key challenges
1. The importance of supervision is well recognised and understood by personnel at all levels. Therefore, supervision aspects were observed to be well covered in the various management systems. 2. The need for supervisors to have management skills such as, interpersonal communication, safety leadership, intervention, coaching etc. commonly called 'soft skills' is recognised and accepted. Training exists for these as well as company initiatives for improvement in these areas. 3. The need for effective competency assurance is recognised and accepted. 4. Management consider that offshore supervisory input to the offshore resource and activity planning process as crucial.	1. The assurance of contractor supervision competency. 2. The provision of adequate supervision. 3. Monitoring of supervisory performance. 4. The assurance of supervisory knowledge and management of safety barriers.

frontline supervisors, who can set standards and challenge unacceptable practices. The importance of effective frontline supervision is illustrated, for example, in the Texas City incident in which the absence of a suitably experienced supervisor during start-up of the isomerisation unit was identified as a contributory factor.

The importance of the frontline supervisory role is not something which is emphasised in general health and safety management system standards, such as OHSAS 18001, yet is a vital component of safety at major hazard facilities. In its training programmes, Centrica has recognised the importance of ensuring not just the technical competence of frontline supervisors but also their behavioural competence, e.g. team leadership skills.

The findings of the Bristol University research are echoed in a recent multi-national audit carried out of supervision in the North Sea oil and gas industry (NSOAF, 2008). This highlighted key strengths and challenges, as summarised in Table 2.

The key role of supervisors is also recognised in a model of safe behaviours used in the offshore industry (see Figure 1), and an earlier study for the HSE in the same industry sector (HSE, 1999) identified the following important aspects of supervisor safety management:

- valuing subordinates;
- visiting the worksite frequently;
- a participative style of management; and
- effective safety communication.

While not an explicit category in the Bristol University research output, the detailed statements and question sets provide a test of the effectiveness of frontline supervision, and the vital role of management in supporting this role.

CONTRACTOR MANAGEMENT

Several of the events studied by the Bristol University team had, as their precursors, the failure of the duty-holder to properly involve contractors and ensure clarity over health and safety requirements. An example is provided by the collapse of the Heathrow tunnels in which contractual arrangements led to significant issues including (i) over-reliance of the client on self-certification of quality by the contractor and (ii) separation by the client of two important aspects of the design – the permanent and temporary works – which led to difficulties in taking an integrated approach to risk reduction. The Port of Ramsgate walkway disaster provided particularly important learning about the roles and 'control' in managing complex projects and this learning was an important contribution to the development of the HSE's Construction (Design and Management) Regulations.

More recently, opportunities for improvement in contractor management have been identified in the Deepwater Horizon incident (BP, 2010), including, as generic themes:

- Definition of acceptable minimum engineering standards and practices by the client;

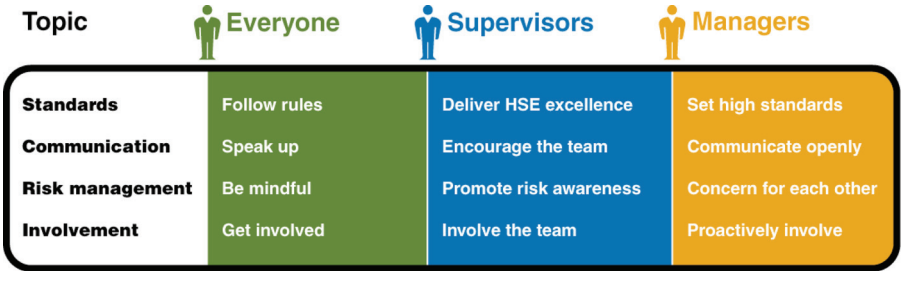

Figure 1. Model of safe behaviours in the offshore oil and gas industry (from Hayes et al., 2007 in turn derived in part from Step Change in Safety, 2004)

- A requirement for the contractor to carry out self-auditing against the above standards and to report to the client to confirm conformance; and
- Testing and verification of conformance by the client through audit.

A model for effective contractor management is provided by the UK nuclear industry which is required to maintain an 'intelligent customer' capability in its contractual dealings (HSE, 2009). The key principles which nuclear licensees are expected to adhere to are as follows:

- To retain overall responsibility for, and control of, the nuclear and radiological safety and security of all of its business, including work carried out on its behalf by contractors;
- To ensure that choices between sourcing work in-house or from contractors should be informed by a clear policy that takes due account of the nuclear safety implications of those choices;
- To maintain an intelligent customer[3] capability for all work carried out on its behalf by contractors that may impact upon nuclear safety;
- To ensure that contracts for work with nuclear safety significance are only let to contractors with suitable competence, safety standards and resources;
- To ensure that all contractor staff are familiar with the nuclear safety implications of their work and interact in a well coordinated manner with its own staff; and
- To ensure that contractors' work is carried out to the required level of safety and quality in practice.

OVERSIGHT AND SCRUTINY

Ensuring independence and encouraging questioning and constructive challenge are vital components of the oversight/scrutiny process. More generally, it is important to define the nature of the audit, review and oversight processes and how they interact. Good practice suggests the need for a layered system with businesses carrying out audit and review of themselves – again with an emphasis on challenge and independence – and the business group management and corporate centre carrying out oversight in such a way as to satisfy their Boards that all parts of the business have good risk control. This can be achieved in a variety of ways, but many events have occurred because leaders at various levels were failing to get – or failing to ask for – information through a well-defined and structured process.

An example of this was the Columbia space shuttle disaster in which NASA's culture was criticised for its allegiance to hierarchy and procedure, while failing to defer to the technical expertise of its engineers. A proper oversight process would ensure that emerging issues are dealt with at an appropriate level, that there is a coordinated response, that remedial actions are effective and that findings inform other business decisions.

Centrica has recently strengthened its oversight arrangements (McBride and Collinson, 2008). This has been done through establishment of two committees: one, comprising senior line management, responsible for setting strategy on HS&E and monitoring progress against it and the other, comprising HS&E heads, which implements the strategy. Centrica is also strengthening its corporate HS&E audit programme, linked to the company's overall internal audit function, to provide greater assurance to the Executive Committee and Board of Directors.

LEARNING

Many events occur because learning from similar, previous events goes unheeded. An example from the events studied by Bristol University is the Longford gas plant explosion. About a month prior to the incident a similar low temperature plant upset occurred, which should have provided warning of operating the plant in the absence of lean oil circulation to the absorbers. This event, however, was not reported in the plant's incident reporting systems and there was no follow-up.

A variety of means are available for improving the effectiveness of learning (Kletz, 1993). These include:

- Ensuring that incident reports (or at least suitable summaries thereof) are widely available;
- Discussing incidents, and their causes, in groups;
- Ensuring that lessons are heeded by feeding them back into training, engineering standards, procedures etc. (ensuring also that the reason for the change is documented and understood);
- Making old incident reports accessible.

In parts of the UK nuclear industry, Operational Experience Feedback (OEF) Engineers are appointed. Their role is to assess the relevance of incoming event reports and ensure that learning reaches the right people, to disseminate their own learning (internally and externally), and to ensure that agreed actions are being followed up.

Because learning from events using conventional approaches involving the dissemination of findings does not always appear to achieve desired outcomes, other mechanisms might need to be explored. One example of this is peer review, common in the nuclear industry and which Centrica has participated in the non-nuclear sector with encouraging results (Sellers, 2008).

MANAGEMENT OF IMPROVEMENT PROGRAMMES

Audits and incident investigations usually result in significant numbers of recommendations which have to be managed, sometimes in the context of organisational

[3]Being an intelligent customer means to:
- know what is required;
- fully understand the need for the contractor's services;
- specify requirements;
- supervise the work; and
- technically review the output before, during and after implementation.

change and/or resource reductions. Several of the events studied occurred because important health and safety issues had not been satisfactorily prioritised and driven to completion. An example of this was the Texas City incident in which a disproportionate emphasis on personal safety, and failure to respond to audit warnings on process safety performance at the refinery, were highlighted. Initiative overload at the site level was also a theme which emerged from this incident.

Parts of the UK nuclear industry have used an approach involving Safety and Environmental Enhancement Plans (SEEPs). These were designed to try to address this issue and to engage the workforce in the process of delivering continual improvement. This helps to develop interest and trust and enables a 'SMART'[4] manageable process to be developed in which the workforce can see that improvements are taking place which recognise their input. SEEPs comprise properly consulted-on, prioritised and resourced improvement actions, coordinated amongst the various levels within the organisation. When done well, they also serve to protect, to an extent, site management against unreasonable initiatives from either the corporate centre or external sources, such as regulators, addressing the 'initiative overload' factor. The intention has been to avoid the generation of 'wish lists' of actions and initiatives which are frequently not seen through to completion and/or the effectiveness is not checked.

CONCLUSIONS

The study of ten major events by Bristol University provides significant insight into the common organisational and cultural causes of accidents across diverse industry sectors. This insight is provided in the form of statements which, if true, would likely have prevented the accidents from occurring. When applied as a predictive tool within a major energy company (Centrica plc) the statements provided a useful pointer to areas of improvement and/or required additional emphasis within corporate safety expectations. Phase 2 of the study pilot study involves application of the detailed questions behind each statement in an operational context (the gas storage business of Centrica). This is expected to provide further insight, whilst allowing some of the draft question sets to be further refined. It is planned that, as part of ongoing research at Bristol University, these question sets will provide the raw material to be fed into a systematic, practical tool of wide applicability, to help organisations to assess their vulnerability to organisational accidents. This modelling has already begun and would involve the use of techniques such as hierarchical process modelling and system dynamics.

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[4]Specific, Measurable, Achievable, Relevant and Timely.

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