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BEHAVIOURAL SAFETY AND MAJOR ACCIDENT HAZARDS
Magic Bullet or Shot in the Dark?†

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In recent years there has been an increase in the use of behaviour modification (BMod) approaches to safety. These interventions generally involve the observation and assessment of certain behaviours, usually those of front-line personnel. The rationale behind behavioural safety approaches is that accidents are caused by unsafe behaviours. These approaches are based on behaviourist theories, which can be summarized by 'behaviour that is strongly reinforced will be maintained'. There are reports of some successes with behaviour modification in a range of environments, including the process industries. Such approaches have a number of advantages in addition to reducing incidents, including increased communication about safety, management visibility and employee engagement. However, these programmes tend to focus on intuitive issues and personal health and safety, ignoring low probability/high consequence risks. The author proposes that the causes of personal safety accidents may differ to the precursors to major accidents and therefore behavioural safety programmes may draw attention away from process safety. Furthermore, the tendency is to focus on individuals and fail to address *management* behaviour, thus excluding activities that have a significant impact on safety performance. This paper discusses the usefulness of behaviour modification approaches, particularly in managing major accident hazards, and provides guidance for companies that may be considering embarking on such a programme.

Keywords: human factors; behavioural safety; major accident hazards; safety management; COMAH.

INTRODUCTION

Major accidents in the oil, gas and chemical industries are by definition high consequence and include major fires, explosions and toxic releases. They are also, thankfully, relatively infrequent. The main legislation focusing on these hazards in the UK are the Control of Major Accident Hazards Regulations 1999 (COMAH). Sites that come under these regulations are required to 'take all measures necessary' to manage their major accident hazards. The Hazardous Installations Directorate of the Health and Safety Executive inspect COMAH sites, assess safety reports submitted by the so-called top-tier sites and investigate incidents on all major hazard sites. This paper is based upon personal experiences of regulating safety on sites that come under the COMAH regulations.

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CAUSES OF MAJOR ACCIDENTS

In any incident there are usually two types of causes:

- direct causes that occur immediately prior to the undesirable event;
- further away, either in time or space, there are underlying causes that contributed to the immediate, direct event.

Historically, many incidents and accidents in all major hazard industries were seen as the 'fault' of someone at the sharp end—the last person who touched the equipment. This view is less common today, particularly in incident investigations, although it is still dominant in efforts to *prevent* major accidents. This paper therefore, argues that there exists an anomalous situation—on one hand industry increasingly recognizes that incidents have underlying causes distant from the person who is directly involved; however, on the other hand, resources to prevent such incidents are often targeted at front line staff.

Reviews of reports into recent major incidents and of research examining the causes of such incidents around the globe tells us the most common causes behind these events. For example, over the years Professor Trevor Kletz has written several accessible books analysing high-profile accidents such as Bhopal, Flixborough, Piper Alpha and Seveso, aiming to show how lessons can be learnt. Discussing the focus on front line staff in reported 'causes' of accidents, Kletz states that: 'Managers and designers, it seems, are either not human or do not make errors' (Kletz, 2001, p.317).

Recent research by Collins and Keeley (2003) shows that although the immediate causes of major incidents frequently involve 'human error' of operators or maintenance personnel, the reasons that these errors occurred in the first place were the responsibility of those more senior in the organization. This research reviewed 718 loss of containment incidents randomly selected from approximately 2500 investigations. Extracts from this research make interesting reading when considering behavioural safety interventions. For example, of 110 incidents due to maintenance, only 17 were due to a failure to ensure that planned maintenance procedures were followed (a front line issue and therefore possibly candidates for a behavioural intervention), but 93 were due to a failure by the organization to provide adequate maintenance procedures (a management issue, which would not be addressed by the majority of behavioural interventions).

Of the incidents analysed, only 5.6% were due to procedural violations—personnel deliberately not following procedures. Collins and Keeley state that 'the cause of any incident or accident, including loss of containment, can usually be traced back to a failure of safety management'. Similar findings were reported in early research on causes of loss of containment incidents by Bellamy *et al.* (1989).

On 25 September 1998, two people were killed in an explosion and fire at the Esso Longford facility in Australia, which led to severe disruption of gas supplies to the State of Victoria's industry and retail customers for two weeks. Longford should be seen as a wake-up call for all of the world's major hazard installations; there are many lessons to be learnt from this incident.

The Royal Commission Report (Dawson and Brooks, 1999) into the accident found that the direct cause of the accident was failure of an exchanger when hot oil was re-introduced after the vessel became cold, following loss of oil circulation during a major process upset. This lead to brittle fracture and the release of hydrocarbon vapour that subsequently ignited, causing explosion and fire. Esso was convicted of breaches of the Occupational Health and Safety Act 1985 (Vic.) and fined a total of $2 million in the Victorian Supreme Court on 30 July 2001. The judge said that responsibility for the tragedy rested solely with the company.

The Longford Royal Commission Report concluded that other contributory factors included:

- failure to conduct a HAZOP study or similar to identify hazards;
- lack of operating procedures for the situation experienced;
- inadequate training of personnel;
- a reduction in supervision;
- transfer of experienced engineers offsite to Melbourne;
- a general desire by Esso to reduce operating costs.

The conclusion from a report into lessons learnt from the Esso Longford disaster by the Institution of Engineers, Australia concluded that:

> 'a combination of ineffective management procedures, staffing oversights, communication problems, inadequate hazard assessment and training shortfalls combined to result in a major plant upset with consequential tragic loss of life' (Nicol, 2001, p.31).

Furthermore, Nicol reports that these issues are relevant to all major hazard facilities; they are not unique to the oil and gas industry. He also reports that other factors increase the chances of disasters, including the increasing age of major hazard plants and an increase in the age profile of the workforce.

The HSE report into the three incidents at BP Grangemouth in May and June 2000 was published in 2003. The foreword to this report, by Dan Mitchell (Head of Land Division, HSE), states that:

> 'Recent work reviewing thirty years of "Large Property Damage Losses in the Hydro-carbon Chemical Industries" . . . shows that there was little new in the events leading to the BP Grangemouth incidents'.

It stated in this report that underlying the failures were a number of weaknesses in the safety management systems on site over a period of time. There were a number of key lessons for major accident hazard sites in this report; including that:

> 'Lesson 1: Major accident hazards should be actively managed to allow control and reduction of risks. Control of major accident hazards requires a specific focus on process safety management over and above conventional safety management.
>
> Lesson 2: Companies should develop key performance indicators (KPIs) for major hazards and ensure process safety performance is monitored and reported against these parameters'.

BP has since committed substantial resources to implementing all of the recommendations made across the Grangemouth complex and the BP group.

ARE WE MANAGING MAJOR HAZARDS?

Statistics published by the HSE show that over the past few years the number of dangerous occurrences has either remained static or worsened. In 2002/2003, three of the UK's nine refineries had major accidents of sufficient seriousness to require notification to the European Commission.

It can thus be argued that current methods of managing major accident hazards are not successful. The review by the Institution of Engineers, Australia, evaluated the impact of the Esso Longford 1998 incident on major hazard sites and concluded that: 'industry and its engineering and safety professionals could have learnt a great deal more from the Longford tragedy' (2001, p.9).

LTIs AND MAJOR ACCIDENT HAZARDS

'Safety' on major hazard sites is frequently measured by lost time injuries (LTIs). Organizations that we inspect frequently present us with very low LTI rates and industry as a whole should be congratulated for bringing down personal injury rates to such low levels. A recent document by the International Association of Oil & Gas Producers

(OGP, 2004) summarizes safety data provided by 36 companies operating in 74 countries around the world. It reports a LTI rate of 1.16 per million hours worked in 2003, which is around a third of the rate a decade ago.

However, several sites that have recently suffered major accidents demonstrated good management of personal safety, based on measures such as LTIs. How can this be when they have managed LTI rates to such low levels?

The reason why companies with good LTI records still have major accidents is that the causes of personal injuries and ill-health are not the same as the precursors to major accidents. A recent research project reviewed the literature on investigation and reporting systems and concluded that measures of injury or fatality rates do not provide an indication of how well major accident risks such as major fires and explosions are managed (Marsden *et al.*, 2004). Earlier work sponsored by HSE (Wright and Tinline, 1994) also concluded that LTI rates are not significantly correlated with loss of containment rates (a measure of releases with major accident potential). This suggests that sites with higher or lower LTIs do not consistently have corresponding higher or lower loss of containment rates.

Measures such as LTIs are not an accurate predictor of major accident hazards and sites may thus be unduly complacent in this respect. Although a focus on personal injuries is important, it is proposed that the balance between resources addressing personal health and safety, and those addressing process safety is inappropriate. Too much focus on measures such as LTIs draws attention away from those aspects relating to major hazard safety. ‘Clearly, a safety management system that is not managing the right aspects is as effective in controlling major accidents as no system at all’ (Anderson, 2003).

An influential account of the fires and explosions at Esso Longford in Australia also emphasizes management and organizational failures (Hopkins, 2000). In this publication Hopkins states that: ‘Reliance on lost-time injury data in major hazard industries is itself a major hazard’.

Unfortunately, the review of lessons learnt from Longford discussed above (Nicol, 2001) suggests that lessons from the disaster appear to have focussed on traditional ‘safety’—aimed at reducing high-frequency, low consequence personal injuries, rather than an engineering focus aimed at reducing low-frequency, high consequence catastrophes.

PROCESS SAFETY PERFORMANCE MEASURES

Major hazard performance indicators should relate to the control measures outlined by the site risk assessment and/or detailed in the COMAH safety report. There is a wide range of process safety indicators available and will relate to issues such as:

- risk assessments and improvements;
- plant and process change;
- functioning of safety critical equipment;
- competency and training;
- resources (financial, staff, equipment);
- procedures;
- plant inspection and maintenance;
- releases and near misses;
- monitoring, audit and review.

For example, performance measures that relate to risk assessments and improvements would possibly include the following:

- percentage of hazard studies completed to schedule;
- percentage of action items completed to schedule;
- number of outstanding action items;
- number of major accident scenarios reviewed;
- number of HAZOP actions not closed out;
- completion of formal risk assessment for the top process safety risks.

However, it should be stressed that process safety management should not simply involve the counting of assessments, audits, reviews or actions etc. that have been completed, but should equally consider the quality of those activities.

ORGANIZATIONAL FAILURES

It is generally accepted that organizational and management factors are implicated in incidents across all industries, from the process industry (e.g., Grangemouth, Flixborough, Piper Alpha), through transportation (e.g., Kegworth, Clapham), to finance (e.g., Barings Bank).

There are many lists of organizational factors that are considered to have an effect on risk. For example, failures by front line personnel may be influenced by training strategies, poor maintenance priorities, inadequate supervision, a failure to undertake effective hazard identification or inadequate auditing. These underlying causes or ‘latent failures’ lie dormant in the organization until certain conditions combine to result in a major incident.

However, it is not enough to implore that organizations should learn from incidents, show management commitment or have a good safety culture without an understanding of how these factors are related to the mechanisms that lead to major accident hazards.

The role of organizational factors is increasingly important with changes in the industry, such as mergers, acquisitions, restructuring, outsourcing and downsizing. These changes are driven by tough competition, deregulation and internationalism and require a deeper understanding of how organizational factors are linked to major hazard risk. These changes can result in loss of in-house expertise, inconsistent standards, loss of corporate memory, dependence on outsourced functions, reduced employee motivation, changes in risk tolerance and a change in process safety management philosophy.

Examples of where management factors may impact on major hazards include:

- the allocation of resources (equipment and personnel),
- the determination of priorities,
- planning and scheduling of work activities,
- levels of capital investment, (e.g., failing to replace out-of-date equipment),
- learning lessons from operating experience,
- management of change,
- competency assurance systems (including for managers),
- the control of contractors,
- approaches to health and safety management (e.g., focusing on those initiatives that are high profile with a perceived quick payback),

- risk analyses, audits and making decisions based upon such analysis.

Errors can (and do) occur in all of these aspects and may have an impact on a whole organization. For example, decisions about staffing levels may exert an impact in two ways:

(1) an inadequate number of personnel available to operate and maintain the site safely, particularly in the event of an upset or emergency;
(2) reduction in morale if employees perceive that they are knowingly 'short-staffed'.

It is also possible for management decisions to be made off-site, for example, from Head Office, which in today's climate may well be outside the UK.

If management and organization factors are important in determining the risk from a major hazard site, then a failure to account for these issues largely renders risk assessment invalid. In recent years, progress has been made in describing and quantifying the links between measures of safety management and quantified risk assessment. These approaches (such as MANAGER, the Sociotechnical Audit Method PRIMA, WPAM and the Dutch AVRIM2 model) assess standards of safety management on site through audit and then modify QRAs accordingly.

HOW DO MAJOR HAZARD SITES ADDRESS HUMAN FACTORS?

Despite the growing awareness of the significance of human factors in safety, particularly major accident safety, many sites do not address these issues in any detail or in a structured manner. Their focus is almost exclusively on engineering and hardware aspects, at the expense of 'people' issues. Those sites that do consider human factors issues rarely focus on those aspects that are relevant to the control of major hazards—they tend to focus on occupational/personal safety rather than on process safety. For example, when addressing maintenance, sites tend to focus on the safety of personnel carrying out such activities, rather than reviewing maintenance error as an initiator of incidents. Human failures in maintenance can have disastrous consequences and are a significant cause of major accidents—common failures include omitting components, using incorrect replacement components or leaving tools inside equipment.

Organizations frequently fail to recognise that there are several different types of human failures (having different causal mechanisms) and tend to focus efforts on selected control measures that have little effect on some failure types.

Where sites do address human factors they tend to focus on two aspects—training and procedures. These interventions may have a positive effect on cognitive failures (decision making errors) and some violations (understanding the reason behind rules and procedures, and better procedures, will help increase procedural compliance). However, improvements in training and procedures will have little impact on unintentional physical failures (e.g., an operator connecting a flexible hose to valve B when they meant to connect it to valve A). Engineering/hardware solutions are the key here, such as changes to valve design so that the hose only connects with valve A. It is not always the case that a human factors problem requires a human factors solution.

Furthermore, when sites claim that 'training and procedures' manage human factors concerns, closer inspection often reveals that these two 'controls' are inadequately managed. For example, in the case of the Esso Longford incident, the Report of the Royal Commission (1999) stated that there were deficiencies in both the arrangements for training and procedures.

Training

'At no relevant time did any programme include training with respect to the hazards associated with the loss of lean oil flow, the hazards associated with the uncontrolled flow of condensate into the rich oil stream from the absorbers, the critical operating temperatures for GP922 and GP905, the circumstances in which brittle fracture might occur or the procedures for the shutdown or start up of GP1'.

Operating Procedures Manual

'It did not contain any reference to the loss of lean oil flow and contained no procedures to deal with such an event. Nor did it contain any reference to GP1 shutdown or start up procedures or the safe operating temperatures for GP905 and GP922'.

One of the ways that major hazard sites address human factors is often through a behavioural safety programme and the later sections of this paper discuss the usefulness of such approaches to managing human performance in relation to major hazards.

When inspecting sites, it is sometimes claimed that a behavioural safety programme is addressing 'human factors'. However, it should be recognized that an intervention focusing on behaviours will not address all human factors concerns. For example, operators motivated towards achieving optimal human performance will not compensate for over-riding production demands, insufficient numbers of personnel, inadequate shift patterns, inadequate process training, unclear roles/responsibilities or outsourcing of technical expertise.

HUMAN RELIABILITY ASSESSMENT AND MAJOR ACCIDENT HAZARDS

Human reliability assessment aims to identify potential human performance issues and the factors that influence performance so that human reliability can be assured. Usually this process starts with analysing the tasks that people perform and identifying potential for error using a taxonomy of error types (e.g., task omitted, task partially competed). Sometimes, attempts are made to estimate the likelihood of the potential for error.

However, most techniques and approaches currently available focus on analysing the behaviours of those personnel in direct contact with equipment, plant and technology. Little progress has been made in the assessment of failures at the design stage; or systemic, organizational and management failures that influence direct failures.

BEHAVIOURAL SAFETY APPROACHES

There has been a large uptake of these approaches over the past 15 years or so. They are based on the premise that a significant proportion of accidents are primarily caused by the behaviour of front line staff. Although these behaviours may be largely the result of attitudes, it has been shown that changing behaviours first is more effective.

There is a wide range of programmes available, but they generally involve the definition of safe/unsafe behaviours, observations of behaviours (by trained observers—either management or employees) and feedback/reinforcement of behaviours. The programmes vary in their detail, for example, according to how safe/unsafe behaviour are defined, who performs the observations, what feedback is provided to individuals (and when) and the nature of reinforcements. The success of these programmes varies widely from reductions in accident rates to no change (or even resulting in a worse situation than previously, for example due to employee disillusionment). Of four detailed case studies examined in an HSE research project, only one demonstrated a significant reduction in accident rates (Fleming and Lardner, 2001). A full description of behaviour modification theory and the key elements of observation and feedback programmes is provided in Fleming and Lardner (2002).

Advantages of Behavioural Safety Approaches

The literature and contact with sites shows that these approaches can be successful in reducing unsafe behaviours in the workplace. Due to the nature of these approaches, there are a number of other less tangible benefits, including:

- management may demonstrate their commitment to improving safety;
- the workforce and management talking to each other about safety;
- increased profile of health and safety;
- increased visibility of management in the workplace;
- employee engagement in safety;
- managers/supervisors learn to act promptly on unsafe acts (and have a legitimate mechanism for doing so);
- managers/supervisors may improve their safety leadership;
- managers/supervisors learn to think about human factors.

Behavioural Safety and Major Accidents

There are two main interrelated concerns with behavioural safety approaches as applied on major hazard sites. Firstly most interventions focus on the behaviours of front line personnel. When the human contribution to incidents is considered, it is often claimed that 70–80% of incidents are caused by 'human error'. However, in my experience, company management usually see the 'human' in human error as referring to front line personnel. Whilst recently investigating an incident with major hazard potential, I was advised by the site senior management that there was a problem with the employee's safety culture. However, the focus should not have been on improving the operator's 'culture' or motivation, but on addressing the management mindset. As with Longford, it was the safety culture of management that required attention.

Safety culture/climate surveys have been very popular in recent years and it is also noted that these initiatives are usually aimed at understanding and optimising the attitudes of front line personnel rather than investigating management attitudes and behaviours.

A focus on individual operators ignores latent conditions that underlie incidents and implies that incidents can be prevented simply by operators taking more care. However, as Hopkins points out:

> 'creating the right mindset is not a strategy which can be effective in dealing with hazards about which workers have no knowledge and which can only be identified and controlled by management' (p.75).

For a traditional behavioural programme to be successful it must identify at-risk behaviours and then observe them with the aim of encouraging safe behaviours and removing unsafe ones. However, we have seen how management and organizational factors have a large influence on accidents and incidents, either directly or through their impact on the behaviours of employees. It is these management decisions and so on, that are usually excluded from behaviour safety approaches (and usually not included in other safety initiatives). In fact, this paper argues that the management decision to initiate a behavioural approach may itself be flawed (e.g., by drawing focus/resources away from process safety).

It is difficult to accept that a traditional behavioural safety intervention would have prevented such a tragedy as that which occurred at Esso Longford—the underlying causes of the incident are clearly outside the control of individual operators. Increased mindfulness or commitment to safety by the operators at Longford would not have prevented the incident because they did not have the appropriate process knowledge (e.g., relating to cold metal embrittlement and critical operating temperatures).

First, management/business consultants frequently investigate management decisions and business strategies; but this expertise is rarely applied to safety. Many audits check for the presence of a system, rather the quality of the products of that system (that is, audits are often satisfied to report that a system of 'audit and review' exists, rather than comment on the quality of that auditing).

Secondly, interventions tend to focus on behaviours relating to personal health and safety; such as the wearing of personal protective equipment (PPE), positioning of the body in relation to hazardous equipment, and issues relating to working at height (e.g., wearing of harnesses, proper use of ladders).

If successful, behavioural interventions will reduce accidents and ill-health of personnel. However, the discussion of LTIs above suggests that LTIs are not a valid indicator of how well a site is managing those aspects that are determinants of major incidents. Behavioural interventions can demonstrate improvements in the wearing of PPE, but this is of little relevance if those wearing the PPE do not have the underlying process knowledge to respond appropriately to a developing incident, or if there are insufficient operators available.

Many supporters of behavioural safety programmes state that large improvements in safety have been made in the past decade or so in engineering and safety management systems; and that new approaches are required to encourage further improvement. Addressing the behaviours of front line personnel is a welcome initiative, but only one tool available. It is inappropriate to concentrate on any one solution to managing incidents and accidents.

Although large advances have been made in engineering and safety management systems, major accidents are still occurring due to failures in these aspects. It is therefore suggested that it is not appropriate to conclude that we have ‘solved’ engineering causes of accidents, nor to assume that no further focus on management systems is required. A publication by the Step Change initiative in the offshore oil and gas industry acknowledges that:

> ‘addressing behaviours must not be seen as an alternative to ensuring that adequate engineering design and effective safety management systems are in place’ (Step Change, 2000, p.5).

We must be aware that exaggerated claims may sometimes be made for behavioural interventions—either in their success at reducing LTI incidents or their impact on major accidents.

Advice for MAH Sites Embarking on a Behavioural Intervention

Cultural or behavioural interventions will only be successful if engineering, technical and systems aspects are in place and adequately managed. Therefore, before major hazard sites embark on a behavioural safety programme, they need to ensure that they have satisfied the following conditions:

- HAZOPs, or similar, have been completed in order to identify hazards;
- the identification and management of human performance in relation to major hazards has been completed;
- the hierarchy of control has been applied to prevent the realization of identified hazards, or minimize their consequences should they occur;
- accurate operating procedures are available for all eventualities, including process upsets and emergencies (e.g., detailing the specific response to critical alarms);
- operators are fully prepared to deal with all conditions, including process abnormalities. This will include identification of training needs, training, assessment, rehearsal and re-assessment. This training should include underlying knowledge of the process, so that operators can ‘troubleshoot’—identify and respond to abnormal situations as they develop—it should not just provide the minimum knowledge required to operate the plant. This will help to manage ‘residual risk’ arising from hazards that were not identified, or effectively addressed;
- the site has the required engineering, operating and maintenance capability and experience (including appropriate staffing levels);
- lessons have been learnt from site, company and industry experience;
- succession planning ensures that corporate knowledge is retained;
- safety management arrangements and risk control measures have been reviewed to ensure that they remain usable and relevant.

Once the above technical and systems issues have been addressed, the site then needs to ask whether a behaviour modification approach is the right approach at this time. Only when the above issues have been addressed can it be assumed that accidents are due to cultural or behavioural factors. In order for a behavioural intervention to prosper, there are several aspects that must be considered, including that:

- there exists an appropriate balance between production and safety;
- there is visible and real management to health and safety;
- there is management commitment and the resources to see it through;
- there is a high level of trust between management and employees.

A recent HSE report (Fleming, 2001) outlines a model for determining the safety culture maturity of an organization and sets out five iterative levels for companies to sequentially progress through. It is proposed in this report that the level of safety culture maturity of an organization should influence the choice of safety improvement techniques. It is clear that a behavioural intervention will not be successful if an organization has not reached a certain level of ‘maturity’.

Finally, once all of the above criteria are in place, if a site decides to embark on a behavioural intervention, the following general advice may be useful (much of which also applies to other safety interventions):

- do not underestimate the resources required—it is not a one-off exercise, but a new way of working that must be maintained for any positive results to be sustained;
- do not be over-optimistic—not all interventions are completely successful in their main aim and many programmes fail the first time. High expectations may lead to later disillusionment;
- do not neglect process safety (beware ‘what gets measured gets done’);
- do be clear about what you want to achieve and how you will know that you have achieved it;
- pilot the intervention (e.g., to ensure that the approach is workable, that the facilitators/observers understand what is required and that the appropriate data is being recorded);
- talk to other similar companies/trade associations about their interventions and experiences;
- as with all interventions, listen to your employees and use the process to improve dialogue—involve employees early in the choice of programme;
- make the language, style, and so on, of the package your own (off-the-shelf packages may not be appropriate for your site/needs);
- use strong site facilitators—the success of such interventions is greatly helped by personable, experienced and respected site personnel as facilitators;
- ensure that the focus is on the root causes of behaviours.

ADVICE FOR MAH SITES ON MANAGING HUMAN PERFORMANCE

Prior to addressing human behaviours in an observation and feedback intervention, it is the author’s opinion that major hazard sites must firstly address the management of human performance in relation to major hazards. It is not the purpose of this paper to detail how this may be achieved, but given the importance of this topic, some brief guidance is provided.

Although the contribution of human failures to incidents is widely accepted, very few sites will proactively seek out potential human performance problems. Unintentional human failures can be physical errors ('not doing what you meant to do') or mental errors, where you do the wrong thing believing it to be right (i.e., making the wrong decision). In addition, there are intentional failures or violations—knowingly taking short cuts or not following known procedures.

In assessing human performance, it is all too easy to focus (sometimes exclusively) on the behaviour of front line staff such as production operators or maintenance technicians—this is undesirable and unproductive. Management/organizational failures have the potential to influence several front line human failures (for example, inadequacies in competency assurance or lack of resources) and should be considered also.

There are two distinct types of human reliability assessment (HRA):

1. **qualitative** assessments that aim to identify potential human failures and optimize the factors that may influence human performance; and
2. **quantitative** assessments which, in addition, aim to estimate the likelihood of such failures occurring. The results of quantitative HRAs can feed into traditional engineering risk assessment tools and methodologies, such as event and fault tree analysis.

There are difficulties in quantifying human failures (e.g., relating to a lack of data regarding the factors that influence performance); however, there are significant benefits to the qualitative approach. The following structure is well-established and has been applied by the author in numerous industries, including chemical, nuclear and rail. This approach consists of seven steps as follows:

(1) Consider the main hazards and risks on the site, with reference to the safety report and/or risk assessments.
(2) Identify tasks where people interact with these hazards in ways that could constitute significant sources of risk if human errors occur—consider maintenance and response to upsets/emergencies as well as normal operations. People may carry out a physical actions, checks, decision-making, communications or information-gathering activities. Consider how people could initiate, escalate or halt an event sequence.
(3) Outline the key steps in these activities through talking to operators, review of procedures, job aids and training materials as well as review of the relevant risk assessment. Describe what is done, what information is needed (and where this comes from) and interactions with other people.
(4) Identify potential human failures in these key steps by considering how tasks could be performed incorrectly. Remember that human failures may be unintentional or deliberate. Consider whether task steps could be omitted, inappropriately or partially completed, or completed at the wrong time.
(5) Identify factors that make these failures more likely—these are known as Performance Influencing Factors, such as time pressure, fatigue, design of controls/displays and the quality of procedures. When these factors are optimal, then error likelihood will be minimized. **Evaluating and improving these factors is the primary approach for maximising human reliability and minimizing failures**. HSE guidance provides a list of such factors.
(6) Manage the failures using the hierarchy of control (i.e., considering eliminating the hazard, prior to assuring human performance through engineering measures such as interlocks, or optimizing Performance Influencing Factors).
(7) Manage error recovery—should an error occur, ensure that it can be identified (either by the person who made the error or someone else such as a supervisor) and recovered from.

CONCLUSIONS

As with the unhealthy focus on LTIs, there is a danger that behavioural modification programmes may draw resources and attention away from process safety issues. The author has recognized above the many benefits of behavioural interventions and does not wish to damage support for interventions that have a positive effect on health and safety. However, organizations embarking on such programmes are asked to retain a balanced approach between personal and major accident safety, and to consider whether a behavioural intervention is right for their company at this time.

The key messages from this paper are:

(1) Behavioural modification interventions are only one aspect of 'human factors'.
(2) These programmes are only one tool in the safety practitioners toolbox.
(3) Know the limits of such interventions.
(4) Prepare the ground before attempting such an intervention.

In conclusion, behavioural safety approaches have their place in the management of health and safety on major accident hazard installations and so they are not merely a 'shot in the dark'. However, there are no 'magic bullets' in health and safety. The key is to adopt a balanced range of approaches, tailored to the specifics of the site.

REFERENCES

Anderson, M., 2003, Human factors and COMAH: A regulator's perspective. *Process Safety: Fulfilling Our Responsibilities*, Conference proceedings, Hazards XVII 25–27, March 2003, IChemE Symposium Series No. 149, 785–792 (IChemE, Rugby, UK).

Bellamy, L.J., Geyer, T.A.W. and Astley, J.A., 1989, Evaluation of the human contribution to pipework and inline equipment failure frequencies. HSE Contract Research Report CRR15 (HSE Books, Sudbury, UK).

Collins, A. and Keeley, D., 2003, Analysis of onshore dangerous occurrence and injury data leading to a loss of containment. HSL Seminar Paper, HSE, May 2003.

Dawson, D. and Brooks, B., 1999, *Report of the Longford Royal Commission: The Esso Longford Gas Plant Accident* (Government Printer for the State of Victoria, Melbourne, Australia).

Fleming, M., 2001, *Safety Culture Maturity Model*, Offshore Technology Report 049 (HSE Books, Sudbury, UK).

Fleming, M. and Lardner, R., 2001, *Behaviour Modification Programmes: Establishing Best Practice*, Offshore Technology Report 048 (HSE Books, Sudbury, UK).

Fleming, M. and Lardner, R., 2002, *Strategies to Promote Safe Behaviour as Part of a Health and Safety Management System*. HSE Contract Research Report CRR430 (HSE Books, Sudbury, UK).

Hopkins, A., 2000, *Lessons from Longford: The Esso Gas Plant Explosion* (CCH Australia Ltd, Australia).

HSE, 2003, BP Grangemouth: Major incident investigation report, 18 August 2003. Available on HSE website at www.hse.gov.uk.

Kletz, T., 2001, *Learning from Accidents* (Butterworth-Heinemann Ltd, Oxford, UK).

Marsden, S., Wright, M., Shaw, J. and Beardwell, C., 2004, *The Development of a Health and Safety Management Index for Use by Business, Investors, Employees, the Regulator and Other Stakeholders*, Research Report RR217 (HSE Books, Sudbury, UK).

Nicol, J., 2001, Have Australia's Major Hazard Facilities Learnt from the Longford Disaster? An Evaluation of the Impact of the 1998 ESSO Longford Explosion on the Petrochemical Industry in 2001 (The Institution of Engineers, Australia).

OGP, 2004, OGP Safety Performance Indicators 2003, International Association of Oil & Gas Producers, Report No. 353, June 2004.

Step Change, 2000, Changing minds: a practical guide for behavioural change in the oil and gas industry, www.step.steel-sci.org.

Wright, M.S. and Tinline, G., 1994, Further development of an audit technique for the evaluation and management of risk, HSE Contract Research Report CRR66 (HSE Books, Sudbury, UK).

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