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APPLYING BEHAVIOUR-BASED METHODS AS PART OF A STRATEGY TO MANAGE PROCESS SAFETY

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Companies are learning that behaviour based methodology is broadly applicable in industry. The successful application, however, is often founded on the premise that they are driven 'bottom up' supposedly by targeting the hearts and minds of the work-force with the sole purpose of addressing slips, trips, falls and other minor incidents often experienced in the workplace. Whilst this has some merit, many hazards and risks are often beyond the control of individuals. It is therefore important to understand the safety obstacles that are encountered by individuals that are out of their control.

Clearly the responsibility for health, safety and welfare at work lies with those who create the risks and those who have to work with them. The paper seeks to examine the culture and behaviour required to manage risk. In doing so it will also consider the influence and impact that management, supervision and the workforce can have on work place safety by considering an approach to applying behavioural-based methods to enhance safety performance in the context of a safety management system within the high-risk environment.

KEYWORDS: Behaviour, Safety Obstacles, Perception, Hazard, Risk, Safety Management

INTRODUCTION

> *In an ideal world, we would be able to design maintain and produce products which generate no waste, in a hazardous free environment. Unfortunately, as we do not live in that ideal world, we must constantly resolve conflict amongst our contradictory needs and desires when managing health and safety risk*[1].

Corporate governance requires that a company's system of internal control needs to embrace a wide range of significant risks associated with different hazards, such as environment, health, safety and quality, as well as the traditional financial hazards such as business failure and fraud. Therefore an understanding of issues such as hazard identification, risk assessment, risk control, risk perception and risk communication is required to appreciate the requirements for managing health and safety risks[2]. Whilst it is suggested that effective management of risk will reduce the potential for accidents and near misses occurring, the very nature of risk assessment means that the probability of an accident and near miss occurring cannot be eliminated altogether: For that reason it is essential that organisations learn lessons as a result of detailed and objective analysis of past accidents

and near miss reports [3]. A reporting culture is therefore, a key element of risk management and consequently a component of health and safety management and governance.

Organisations that have the cultural 'competence' and 'capability' to capture and manage leading and trailing data are able to develop a holistic understanding of the causation and then generate remedial actions to prevent similar occurrences in the future. Furthermore, such information also provides opportunities for exploring gaps within an organisational risk management philosophy and practices, as part of a continuous improvement process [4]. Given that the behaviour of management is the most critical element in creating a culture of safety in any organisation, it could be suggested that the refinement and development of key leadership and management behavioural traits could have the greatest impact on an organisation's safety performance.

"Behaviour breeds behaviour"

AIMS

Since the responsibility for health, safety and welfare at work lies with those who create the risks and those who have to work with them, this paper seeks to examine the culture and behaviours required to manage risk. In doing so the paper will consider the influence and impact that management, supervision and a workforce can have on a culture of safety. Finally, the paper will consider an approach to applying behavioural-based methods to enhance safety performance in the context of a safety management system within the high-risk environment.

DEFINITION OF HAZARD AND RISK

Risk has several levels: first, as a statistical concept of measuring the likelihood of damaging events occurring. Second, also as a statistical concept but this time also taking the degree and type of impact into account. Third, there can be an emphasis on the distribution of power, cost and benefit in society and its stakeholders, who ultimately bear the imposed risk [5]. Fourth, the perception of risk, which can be characterised as a battleground, marked by strong and conflicting views based on an individual's beliefs, attitudes, judgments, feelings and disposition adopted towards hazards and their benefits [6].

The Royal Society defines risk management as

> *The process whereby decisions are made to accept a known or assessed risk and /or the implementation of actions to reduce the consequences or probability of occurrences* [7].

Hazards are defined as the threats to people and the things they value[8]. In this paper people's physical and mental well-being are the key hazards being investigated. It needs however, to be recognised that hazards also have their benefits, for example motorised transport in its many forms has risks attached that are widely accepted. The issue therefore becomes one of what level of risk is acceptable and how it should be managed so that people can make their decisions based on an agreed set of standards or principles.

REGULATORY FRAMEWORK

The Management of Health and Safety at Work Regulations 1999 place a variety of duties on employers relevant to the management of controlling risk. Regulation three specifically requires employers to carry out an assessment of the risk to their employees and the public, stemming from their work activities [9]. The purpose of the assessment is to identify the measures the employer needs to take, also to highlight and comply with other relevant legislation, for example the Control of Major Accident Hazards Regulations 1999 [10].

The COMAH Regulations came into force on 1st April 1999 to comply with the Seveso II Directive (96/82/EC) (*except for the land use planning requirements*), and replaced the Control of Industrial Major Accident Hazards Regulations 1984 (CIMAH). COMAH applies mainly to the petroleum and chemical industry, but also to some storage activities, explosives and nuclear sites, and other industries where threshold quantities of dangerous substances identified in the Regulations are kept or used. Following on from this assessment, employers are required to organise their activities so that measures identified are put into effect. Process related equipment failure or ruptures, which result from procedural or human error, metallurgy failure, or equipment malfunction, have the potential to escalate into large-scale releases with devastating consequences, for example fires, explosions and toxic effects to people and the environment unless prevented by pre-planned responsive measures or layers of protection.

> *The principal aims of COMAH are therefore two-fold; firstly goal orientated prevention of major accident hazards involving hazardous substances by placing emphasis on the socio – technical aspects of any control policy. Secondly as accidents will inevitably occur, to minimise any potential consequences of such accidents not only for mankind but also the environment* [11].

Within the boundaries of the petrochemical industry, PSM (Process Safety Management) embodies the measures and activities required to achieve an acceptably safe operation. It is intended to provide significant benefits to a plant by setting standards and provide the framework that encompasses the guiding principles and philosophy in the form of procedures and guidance, all translating into the strategy, tactics and critical activities captured and documented in a safety case. These arrangements typically adopt the recommended format of HSG (65); policy, organising, planning and implementation, measuring performance, auditing and review of performance [12]. Ultimately an effective safety case should result in predictable business operations with fewer losses and with other direct benefits, for example fewer leaks, a reduction of production upsets, improved 'up' time, also a better trained and informed workforce all culminating in an enhanced reputation and relationship with the stakeholders and regulatory authorities. The safety case therefore is intended to provide a high level of confidence by clearly highlighting the necessary provision and intent to deal with the containment and management of

potential release of hazardous chemical substances throughout a process life cycle whilst ensuring compliance with legislation, in particular the COMAH Regulations.

LOST OPPORTUNITY: *POTENTIAL HAZARD AND OPERABILITY PROBLEMS*

The technique of hazard and operability study, or in more common terms HAZOP, was initially developed by ICI in the United Kingdom, with the technique starting to be more widely accepted and used within the chemical process industry after the Flixborough disaster in 1974. This chemical plant explosion killed twenty-eight people and injured scores of others, many of those being members of the public living nearby. Through the general exchange of ideas and personnel, the system was then adopted by the petroleum industry, which has a similar potential for major disasters. This was then followed by the food and water industries, where the hazard potential is as great, but of a different nature, the concerns being more to do with contamination rather than explosions or chemical releases.

HAZOP has been used and developed over approximately four decades for identifying potential hazards and operability problems caused by deviations from the design intent of both new and existing process plants. Whilst HAZOP is intended to establish an approach to risk management either "strategically" by adopting inherent or passive methods or "tactically" with active or procedural controls, any final outcome is ultimately reliant on a company's management to adopt and support the approach to any recommendations made.

Inherent and passive approaches must be implemented early in the development and have a broad and wide impact on process design. It is therefore, important to make a clear connection with the business case to support the safety life cycle approach to risk management, as the most notable penalties are time, money and injury. It is therefore argued that at the research and conception stage there is opportunity to influence the level and detail of inherent safety that is built into a process, because this stage defines the fundamental approach of a new project. To put this into fiscal perspective it has been suggested that to eliminate a safety related problem at conception stage would cost \$1, \$10 to eliminate at the flow sheet stage, \$1,000 at the production stage, and \$10,000 at the post-incident stage [13]

Whereas there is a fiscal or time restraint leading to a temptation to defer or opt for the tactical '*active or procedural controls'* which can be implemented later in the design process, they unfortunately tend to be characterised by repetitive actions and viewed at a later date as short sighted. Furthermore, this repetition has the potential to be associated with high costs of operations and maintenance, in addition to a higher likelihood of human induced error.

Herein lies a problem, as currently there are a number of industries that have to manage the 'built in' inherent risks created by a failure to adopt any recommendations made by HAZOP and similar studies which thereby inadvertently created undesirable situations.

The behaviour of designers, management and engineers significantly influence, not only the safety of a process, but also the resulting behaviour of those who are asked to operate them. Clearly if equipment is designed or built with a lack of inherent controls and layers of protection there is always going to be a potential for undesirable impact on plant integrity and people.

Broken pipes, broken tools, People bending broken rules[14].

UNDERSTANDING THE ISSUES

Industry, along with all aspects of human survival and endeavour, relies on the input and behaviours of individuals to a great extent. This is particularly critical in high risk industries where flawless operation, legal compliance and safety exemplar are a prerequisite.

Since accidents occur with less frequency than unsafe situations, unsafe conditions and human errors, we can often learn as much from the recovery of an error, or equally the way that personnel work around inherent problems, as from any potential consequence. Central to this therefore, is the behaviour of human operators, who are a fundamental component of the safety of any complex socio-technical system. Typically in these settings, to a large extent critical real-world problem solving behaviour takes place in dynamic, event-driven environments, where partially ambiguous or conflicting cues appear gradually and situations evolve in both an intrinsic and extrinsic way in relation to the actions taken by operators[15].

These situations, in which people have to amass, rationalise and make decisions based on uncertain, incomplete and changing evidence, occur constantly at all organisational levels. However these situations are all to often over looked or are taken for granted and simply passed off as "thinking on your feet" or applying "common sense".

In complex environments, case studies have shown that often there is a reluctance to report or indeed in some cases, revise, situational assessments with new evidence. Such errors are often initially quite difficult to identify and often manifest later in the evolution of undesired events, where people and organisations have not succeeded in updating their view of a situation or condition, in spite of cues that can in retrospect be recognised as indications or near misses[16].

This is reflected in Turner and Pideon's book titled Man Made Disasters[17] when they refer to inconsistent levels of hazard recognition and response or to put it another way risk tolerance, risk acceptance and the perception of risk.

There are many problems associated with these elements of risk management, for instance it effects decisions and action on risk identification, risk estimation, risk evaluation and risk mitigation[18].

Perception is not determined simply by stimulus patterns: rather it is a dynamic searching for the best interpretation of the available data. Perception involves going beyond the immediately given evidence of the senses[19].

ALARP (as low as is reasonably practicable), QRA (quantative risk analysis), LOPA (layers of protection analysis) etcetera are not adopted by people when making every day judgements about risks. Often these are purely subjective assessments which are left to individuals based on their own frame of reference or perceptual set which tends to differ vastly from one person to the next. An individual's perceptual set is part of their internal make up and is formed drawing from a culmination of elements such as experience, personality and motivations. This leads to many problems associated with the defining of acceptable and tolerable levels of risk. Fischoff, B., Lichtenstein, S., Slovic, P., Derby, S.L. and Keeney, R.L. (1981) [20] captured these under five categories:

- Uncertainty associated with defining the problem
- Difficulties associated with assessing the facts
- Difficulties associated with assessing the risk values
- Uncertainties about the impact on humans
- Difficulties associated with assessing the quality of the decision.

One reason therefore, why employees do not report near miss data / hazards are because they do not perceive the magnitude of a potential hazard. Typically, this is because they recover from situations before they degenerate into accidents and for that reason often remain unclear at which point a situation is deemed a near miss. To remedy this, management systems need to have the ability to recognise, 'tease out' and capture operational weaknesses and close any gaps through action. The example above also illustrates the importance of clarifying, capturing, assimilating and acting upon precursory data, which has the potential for catastrophic consequences. The reality is that, as behaviour is the last link in a casual/causal chain, it is not necessarily the most effective link to focus on as the cause, albeit an important piece of the jigsaw. Unsuccessful behaviour programs therefore run the risk of assuming that at-risk behaviour is the only cause of accidents worthy of focus, often with a tendency to blame individuals.

Whilst it is acknowledged that some unsafe acts or at- risk behaviours are egregious or blatantly obvious, the vast majority are not. Another serious weakness of the person approach is that, by focusing on the individual origins of error, it isolates unsafe acts from their system context. As a result, two important features of human error tend to be overlooked. Firstly, it is often the best people who make the worst mistakes. Therefore, error is not the monopoly of an unfortunate few. Secondly, far from being random, mishaps tend to fall into recurrent patterns. The same set of circumstances can provoke similar errors, regardless of the people involved. The pursuits of greater safety are therefore seriously impeded by an approach that does not seek out and remove the error provoking properties within the system at large. This was highlighted by Heinrick [21] when he developed the first model of human error based on the concept of cause and effect: this model is commonly referred to as the *domino theory.*

Heinrich's argument was that a number of factors act like a row of dominoes and if one was knocked over they would all be impacted resulting in an accident. Similarly, Reason presented us with a model of accident causation based on the concepts of latent

and active errors. He claimed that very few latent or active errors actually result in harm to people or the environment because normally most operational systems include sufficient layers of defence to prevent an accident[22]. Likewise, as previously mentioned, over time operatives build up a catalogue of counter active behaviours that they can call upon to defuse a potentially hazardous situation. It is only when all the unsafe acts, unsafe situations/conditions and human errors occur concurrently or in the right sequence that an accident may ensue.

So how do we manage these inherent problems that often have the potential to contribute to undesirable situations manifesting as a by-product of front line behaviours?

RETRO OPPORTUNITY

Effective organisations deal with the dilemmas arising from these issues with a collective mindfulness. This approach is distinctive because it is closely related to the plethora of action and capabilities of individuals and organisations. Weick, Reason and others alike make this point when they argue that these practices are the focal point of a culture of safety[23].

> *Mindful organisations understand that long periods of success breed complacency and they are thus wary of success and therefore preoccupy themselves with the possibility of failure*[24].

These types of organisations actively seek for lapses, errors and inconsistencies, recognising that these may be precursors to larger failures. Hence, they have well developed systems for monitoring and reporting near misses, process upsets and system failures in order to make decisions to move forward. Furthermore, they encourage their workforces to be more vigilant, explore the unknown, continually learn and improve. Moreover, mindful organisations have a positive safety culture, in which they see the value in health and safety performance and recognise the critical success factors to achieve this goal and therefore provide resources to develop the skills and competencies to utilise tools and, in addition, embrace and employ them in pursuit of safety performance exemplar.

FUNDAMENTAL KEY CONCEPTS: WORKFORCE BEHAVIOUR

> *So how does all this pull together in the work place?*
> *What does it look like?*
> *And how can it add value?*

Total control may only be fully realised through the seamless interaction of both hard and soft controls and management systems. To focus solely on changing individual behaviour without considering necessary changes to how people are organised, managed, motivated and rewarded, along with their physical work environment, tools and

equipment, can result in treating the symptoms only, without addressing the root causes of unsafe behaviour.

The subsequent process follows a number of key principles:

1. Understanding behaviour.
2. Identifying Operational Safety Critical Tasks.
3. Identifying the relevant corrective action;
   - Management behaviours provision of an engineering fix or resource.
   - Workforce operent behavioural modification

1. Understanding behaviour and fundamentals is a critical success factor for organisations that utilise behavioural modification successfully. Skinner's (1937)[25] behaviouralist approach considered this to consist of two facets. These facets help us understand when employee driven change is appropriate and when it is not. First, respondent behaviour which refers to actions produced when a stimulus triggers a natural response (classical conditioning), such as that observed during excitement or fear. This is very difficult to modify. However, the second 'operant' behaviour refers to the response to environmental factors, for example driving a car which is a behaviour that can be influenced and modified. Operant behaviour is learned from reinforcing a process of conditioning, which is used to shape future behaviours in a way that produces behaviours that would not normally appear spontaneously (Keil Centre, 2000)[26].

It is important to note that operant behaviour can also be influenced by affiliation bias. Affiliation bias can be defined as an individual's view on risk influenced by factors such as (*over*) familiarity and self-interest leading to potential understatement or overstatement of risks. Again the example of people's behaviour whilst driving a car is relevant, when you consider the different behaviours adopted between safe and unsafe drivers. The calibration of affiliation bias by modifying operant behaviour will bring about a grounding of risk perception and subsequent risk bias. Modifying operant behaviour can be achieved by dealing with the issues of cognitive dissonance.

Cognitive dissonance relates to how individuals change their attitudes to certain issues if two or more pieces of information or views are in apparent disagreement. When this occurs we tend to feel uncomfortable as our behaviour is out of line with our values. Individuals usually deal with this in one of four ways:

- Ignore one or more pieces of information,
- Change one or more of their views,
- Introduce a new factor
- Change one of the existing factors.

Thus, if an organisation constrains an individual to behave safely by modifying their operant behaviours it needs to align the above if it is to be valued and sustainable. Alignment may simply require feedback or communication which should not be underestimated. However, there are many occasions where there is a need for management intervention

supported by action and resource, all of which are constructs of clear and visible positive management behaviours and a demonstration of their commitment.

To understand the safety obstacles, safety critical operant behaviour is further divided into three specific categories which can indicate when behavioural modification is applicable within a frame work of physical and management controls.

Thus;-

Enabled behaviours are where an activity can easily be carried out safely with minimum effort or time required from the individual. This can be seen in situations where personnel have to make a simple choice such as using the correct tool or behaviour for a specific task.

Difficult behaviours are where the task can be carried out safely, however, more time or effort is needed. Again this can be observed in situations where an individual should stop what they are doing and go and seek further assistance or retrieve another tool in order to perform a task safely.

Non-enabled behaviours are when, no matter how much the individual desires to carry out the task safely, given their current work situation or individual abilities they cannot perform the activity in a safe manner. Typically this is where facilities, equipment, procedures or training are deemed to be insufficient. Since many hazards and risks are typically beyond the control of an individual it is also important to understand the safety obstacles.

2. Identifying Operational Safety Critical Tasks. Identification of critical tasks and the behaviours associated with them are key to successful observations and hazard identification. Before attempting to measure behaviour, there is a need to clearly identify and define the critical aspects of any activity in order to ensure that these behaviours can be monitored and compared on a like for like basis. Only by seeking to understand why a particular behaviour is demonstrated are we able to establish how modification of this behaviour may be undertaken. For example, the commissioning of a furnace involves numerous safety critical activities, often with a heavy reliance on individuals and their interpretation of working procedures. The behaviours adopted during such activities will typically be influenced by an individual's affiliation bias. These, like all behaviours demonstrated in the workplace, can be captured in an operational safety critical behaviours (OSCB's) register if deemed critical. This register needs to be supported by standards, procedures and best practices. Such a register will enable a non-subjective appraisal of critical tasks, providing a clear insight into any deviations from the behavioural norm.

For example;-

- What was the deviation?
- Why was such behaviour adopted?
- Was there an awareness that a deviation occurred?
- Can this behaviour be controlled by the individual?

Figure 1 provides a structured approach to address safety obstacles enabling a dovetailing of both behavioural modification and management intervention, thereby ensuring that the

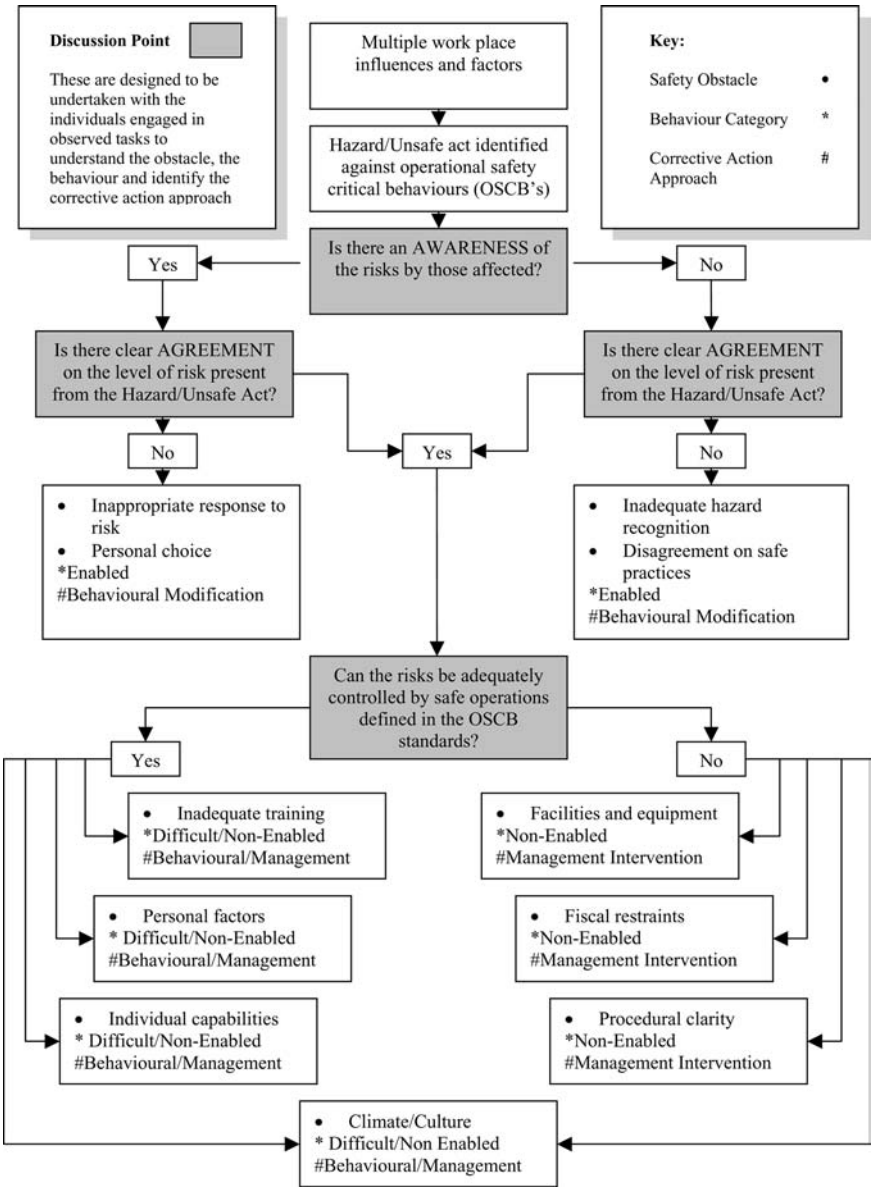

Figure 1. Marsh. C., Fair. R. (2005). Safety obstacle resolution model

appropriate action is instigated by focusing in the area where it will have a maximum impact bringing about the desirable outcome.

3. Providing a Management/Engineering fix. As previously discussed, the reporting of hazards is a particularly important way of preventing and highlighting accident potential. Indeed for some proactive organisations there can a frustration around the behaviour or willingness to contravene explicit safety rules, procedures and /or training to get things up and running. This mindset or perception often results in people throwing caution to the winds in order to get over a hurdle. Indeed, many studies have established that major accidents are always preceded by warning signs and indicators that the hazards concerned are not appropriately controlled[27]. On the occasions where indicators are responded to in a timely fashion, accidents are often averted. This also applies to situations where there is recovery. This is why any employer who seeks to introduce a behavioural safety system and wishes to convince its workforce that it is serious about safety, needs at the same time to introduce or energise a system for dealing with the emerging safety obstacles. The mere identification and reporting of hazards is not enough if sincerity about safety is to be established so far as a workforce is generally concerned. Therefore, any safety obstacles or issues that are raised need to be acted upon efficiently.

The suitability and application of behavioural modification must also be understood by management and supervision to ensure that there is not an over reliance upon this approach to improved safety performance, enabling participants to believe that such a process is seen to be a valuable addition to the safety improvement arsenal and not just a cheap or easy option to problem solving or a convenient 'opt out' from carrying out hard fixes. This can only be achieved by having a clear understanding of the obstacles to safe working and safe operations. For this reason it is important to tease out and deal separately with behaviour modification issues from situations which can only be influenced by management such as engineering fixes or resource availability.

Once the safety obstacles that are beyond the control of the individual have been identified, a suitable solution can be sought by engaging the correct personnel within an organisation. There are few (if any) tangible benefits to preaching to individuals about the need for change when the root cause of an issue is substandard plant or equipment which has passed its safe serviceable limit (*at the other end of the bath tub curve*) or procedures which are unworkable or impractical.

CONCLUSIONS

Corporate governance requires that a company's system of internal control needs to embrace a wide range of significant risks associated with different hazards, such as environment, health, safety and quality, as well as the traditional financial hazards such as business failure and fraud. Consequently, where health and safety issues present a significant business risk these risks should be incorporated into the organisation's system of internal control. (Vassie, L. 2004:1)[28]

Since the responsibility for health, safety and welfare at work lies with those who create the risks and those who have to work with them, this paper has sought to

examine the culture and behaviours required to manage risk. The aim of this paper was to discuss the methods in which an organisation's management and workforce can influence and impact a culture of safety. The paper also considered an approach to applying behavioural-based methods to enhance safety performance in the context of a safety management system within the high-risk environment.

The preceding discussion has implicitly raised several limitations of conventional safe behaviour programs. Management behaviour is always a factor contributing to accidents. Since behaviour breeds behaviour, what managers attend to and the standards they set, are the examples that are followed and valued. This is a crucial determinant of organisational outcomes (Hopkins, A. 2000)[29]. This was established by Fleming and Lardner[30] some years ago when they identified a number of management qualities to support behavioural based processes, for example, positive feedback; also, the effective response to safety concerns raised and subsequently followed up on. Clearly these actions are necessary in order to produce useful measures of management and leadership behaviour within a process.

Decision making behaviour by management can contribute positively or negatively to any safety outcome. Currently within industry, however, there remains a lack of understanding with regard to behavioural interventions in the arena of management judgement and it therefore frequently fails to capture some of the most crucial management and workforce behaviours. There are few (*if any*) tangible benefits to preaching to individuals about the need for change when the root cause of an issue for example, is substandard plant or equipment which has passed its safe serviceable limit, or where procedures are unworkable or impractical. On these occasions all that a behavioural process will deliver is safety rhetoric and a lack of buy in.

The paper has illustrated that there is a fundamental need to provide a mechanism or process to identify and understand safety critical behaviours and any subsequent appropriate action required to address safety obstacles. A well-run behavioural system, where line management and employees can see their concerns treated seriously and acted upon, is a very powerful catalyst for future reporting and adds significant credibility to the process. It can also provide a timely reminder of the prevalent hazards and a means of monitoring and communicating their potential as they reoccur during the lifetime of an application or process.

Organisations that positively embrace an informed culture of safety, where they see the value in health and safety performance and recognise the critical success factors to achieve this goal, are more likely to provide resources to develop the skills and competencies to utilise tools and systems such as behavioural safety in pursuit of safety performance exemplar. (Hopkins, A. 2000). (Weick, K. Sutcliff, K. Obstfed, D. 1999). (Reason, J. 1998)[31].

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