

Process Safety Behaviours: What are they and how to they link to Occupational (Personal) Safety Behaviours

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Occupational (Personal) Safety behaviours are well understood and successful programmes have been implemented worldwide to promote safe behaviours and eliminate unsafe behaviours. Process Safety behaviours, in contrast, have not been well defined and efforts to define them and improve them have been fragmented. In the well-known Process Safety triangle, the base of the triangle is often stated as "Unsafe behaviour or insufficient operating discipline". This is not usually illustrated by examples and implies that the only important Process Safety behaviours are those of the front line operating staff. Programmes to eliminate or reduce the incidence of poor Process Safety behaviours, however defined, have been minimal and there is little guidance on changing the impact of subtler Process Safety behaviours by, for example, engineers.

By their nature, Process Safety behaviours can often be remote from the actual incident and consequence and the behaviour might have occurred months before the incident.

The author will suggest several useful guidelines and recommendations from 30 years of running hazardous plant, dealing with many incidents and 18 years of consulting as a professional process safety engineer. These will deal with the following: What are typical Process Safety behaviours that are required for:

- operating personnel
- engineering staff
- management

The links between Process Safety and Occupational Safety (Personal Safety) will be explored. The relationship between Process Safety behaviours and broader aspects like organisation culture and leadership will also be examined. The author will also include consideration of studies done on organisational decision making such as was evident in disasters like the Deepwater Horizon oil rig fire and explosion.

KEYWORDS: Process Safety Behaviours, Occupational Safety, Major Hazards

Introduction

Safety behaviours have been studied for many years in the field of Occupational Safety. Much more recently the concept of Process Safety behaviours has been created and the understanding of these behaviours is still being developed. Occupational Safety (Personal Safety) behaviours are simple to understand and there is a direct link from the unsafe behaviour to a resulting accident. On the other hand, Process Safety behaviours can cover a wide range of activities some of which are simple and have a direct consequence like an Occupational Safety behaviour but can also be very indirect and occur months or years before the actual incident.

Behaviour Based Safety programmes have been very successful in reducing Occupational Safety accidents. No analogous programmes have been set up to handle Process Safety incidents where consequences can be so much more severe.

The well-known Bird / Heinrich Triangle has been well established and used in Occupational Safety. Variants of a similar triangle have been proposed for Process Safety but are not regarded as complete now.

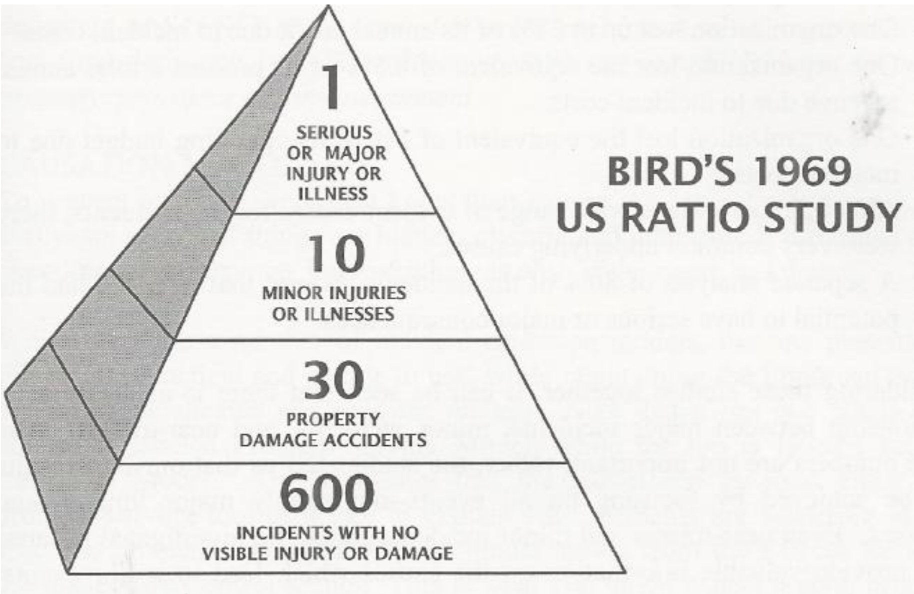
The terms Occupational Safety and Personal Safety will be used interchangeably in this paper.

Safety Triangles

The Bird / Heinrich triangle for occupational safety

Frank Bird popularised the Safety Triangle in 1969. The triangle (see Figure 1 below) showed a fundamental relationship between serious accidents (fatality) and lesser accidents or near misses (Ref.1). The HSE (1993) confirmed the relationships but with slightly different figures.

Figure 1 Frank Bird' triangle showing the relationship of different levels of accident severity



The value of the concept lies in the ability to reduce the size of the base of the triangle and consequently reduce the risk of the serious outcomes with the assumption that the ratios of the different incident severities remains much the same. Attention paid to the pyramid base (unsafe behaviours) has paid off for many companies. In Occupational Safety, the behaviours that could be reduced through structured interventionist programmes included:

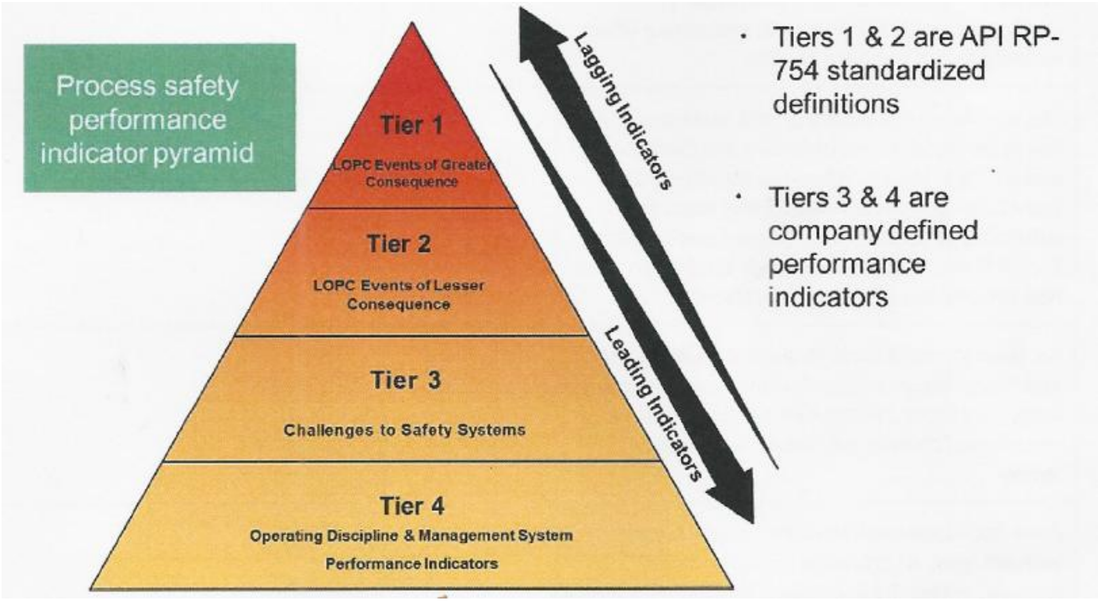
- Not wearing PPE
- Not working "in line of sight" of a hazard
- Working at heights without a harness
- Tripping over hazards
- Slipping in spills

Should such a similar relationship exist for Process Safety, then a targeted approach could be considered to reduce Major Incidents.

Process safety triangles

The most common used Process Safety Triangle is shown in the API Standard API RP 754 (Ref 2). It is shown in Figure 2 below.

Figure 2 – API RP 754 triangle showing the different levels of Process Safety incident severity



The model is a simple 4 – tier pyramid with the layers being:

- Major Incident - Large loss of primary containment or facility
- Smaller Incidents – Loss of containment
- Challenges to safety systems
- Operating discipline or management system degraded

No ratios have yet been suggested for the relationship of the 4 layers. The terms "Major", "Smaller" have been defined and successfully used by some companies. The two bottom tiers (Tier 3 and 4) have general titles which does not suggest obvious actions although the API have given some examples. A Tier 3 example might be the closure of an inlet valve to an oil / gas separator because of a liquid surge but after draining the excess liquid normal operations resume (the safety system was challenged). A Tier 4 example might be a process engineer missing part of a HAZOP required for competency training because of other priorities (insufficient operating discipline). The API suggests that companies develop their own Tier 3 and 4 performance indicators.

The IChemE have come up with a modified version of this triangle and it is shown below in Figure 3.

Figure 3 – IChemE triangle showing the relationship of unsafe behaviours and attitudes to Process Safety accidents

This is still a "work in progress" but the bottom layer remains unsafe behaviours (and attitudes). Should it be possible to identify these and develop corrective actions, then a more focussed approach to improving Process Safety behaviours can be taken. Of course, Process Safety also depends on equipment integrity, the provision of adequate safeguards and management systems but human behaviour is a major factor in many major accidents. At present, there are no agreed ratio figures for Process Safety triangles but the same principle used for Occupational Safety incident reduction (reduce the base of the pyramid) can be applied for Process Safety. The experience of the leading chemical firms in Process Safety suggests that this is a sound approach.

Methodology

It is possible to suggest some useful guidelines and examples of Process Safety behaviours from both personal experience and from the history of incidents in the process industries. The author has spent 30 years of running hazardous plant, dealing with many incidents and 18 years of consulting as a professional process safety engineer. It is useful to think of Process Safety behaviours relating to the following job categories:

- What are typical Process Safety behaviours that are required:
  - for a panel operator?
  - outside operator?
  - process plant supervisor?
  - plant manager?
- What are typical Process Safety behaviours for engineering?
  - Maintenance staff?
  - Design engineers?
  - Project engineers?
- What are the typical Process Safety behaviours for management?
  - Site management?
  - Senior management?

The lists of behaviours are illustrative and are not meant to be exhaustive in any way.

Operating process safety behaviours

These examples come from personal operating experience and consulting over a period of 18 years.

<u>Panel Operators</u>

- Response to alarms – should be quick (seconds) and effective whether for control actions or safety actions.
- Never tolerate nuisance alarms which keep going off for low level gas excursions
- Understands and remains within the operating envelope, understands the alarm envelope and design envelope. On questioning, should be able to describe the consequences of going outside the envelope.

- Can describe all the trip and alarm functions, can explain the testing requirements and be able to get confirmation that this has been done.
- At the start of the shift checks that the communications with all other operators / others is sound. If not, get these repaired as a matter of urgency
- Reports any faulty or suspect instrumentation on the same shift as was discovered and follows up to see if repaired
- Is satisfied that the operating instructions are accurate and useful and, if not, has put in suggestions for their improvement
- Is aware of any “alarm flooding” situations and has reported them
- Knows the correct response to any identified process upsets
- Is very clear about what equipment is running and what is not
- Has pointed out any poor ergonomic situations on the panel
- Is alert to any unexpected deviations and has a plan to rectify
- Is watching out, as far as possible, for colleagues who may be fatigued or unwell
- Hands over the shift with both verbal and written communications so that the incoming operator is effectively briefed on plant performance, ongoing issues and plans

<u>Outside Operators</u>

- Knows what equipment is running or not
- Is clear about any planned shutdowns, start-ups or production rate changes planned for the shift
- Is aware and monitors all maintenance in the area
- Knows his section intimately i.e. all items of equipment, all fluids in the various pipes
- Reports any trip hazards, poor lighting etc. on the same shift they are discovered
- Reports any poor equipment numbering situations which may give rise to errors. Insist on an MOC and get the situation rectified.
- Knows all equipment which has been rated “safety critical”, why and what extra attention must be paid to them
- Always wear the required Personal Protective Equipment (PPE)
- Knows the major hazards on the plant, the related safeguards and the checks he must make to ensure they remain “fit for purpose”.
- Tests the communication devices at the start of the shift.

<u>Supervisors</u>

- Spends >80% of available time checking critical actions by operators and explaining reasons for advice given to operators
- Trains the operators in the Basis of Safety (BOS) and ensures they understand the plant safeguards and how they relate to major hazards
- Is present to shadow operator control during start-ups, shutdowns and plant upsets
- Hands over shift formally in the control room. Offset the handover by a few minutes if possible from the operator handover
- Understands the role and behaves as if the supervisor is an independent layer of protection

<u>Plant Managers</u>

- Understands what the safeguards are for preventing and mitigating major incidents
- Ensures that the safeguards are healthy by regular checking both physical safeguards and test data records for items like trips
- Coaches subordinates in sound process safety behaviours
- Reviews shift reports and investigates any abnormal conditions and trends
- Plays a full role in any Management of Change (MOC) proposals
- Ensures by means of audits that critical Process Safety systems like Permits to Work and Planned Task Observations work effectively
- Practices active learning from incidents on similar plants
- Walks the plant and detects any reasons for feeling the “unease”. Follow up on any abnormalities like motor bearings running hot
- Knows all equipment which has been rated “safety critical”, why and what extra attention must be paid to them
- Monitors leading indicators for Process Safety and investigates unhealthy trends

Engineering process safety behaviours

Maintenance Staff (artisan, supervisors)

- Only performs tasks for which fully competent
- Be trained and retrained regularly for performing the acceptor role in Permits to Work
- Maintains a healthy sense of suspicion as to the hazards of doing repairs – not all hazards may have been identified
- Understands the plant hazards in general and specific hazards of substances like hydrofluoric acid or special equipment hazards like radioactive sources
- Understands the critical role of asset integrity to overall Process Safety
- Repairs faulty equipment like level measurement very rapidly
- Ensures records of repairs / replacement are accurate and entered into data bases on same shift
- Knows what the plant Safety Critical Elements are and ensures they get priority attention in the event of failure
- Performs scheduled checks and replacements as per plan paying special attention to any item designated as safety critical
- Maintains a watching brief on all contractors working within a designated area. Any Process Safety deviations must be dealt with immediately. For example, a contractor who strays outside his designated area into hazardous operation plant should be intercepted quickly, returned to his "safe area" and the risk of his actions explained.

Design Engineers

- Uses applicable Codes (API etc.)
- Uses applicable Codes correctly
- Makes use of any existing operating experience
- Understands the principles and practices of PSM including failure mechanisms and failure rates for specific types of equipment
- Carries out the appropriate Hazard Studies for the stage of design (FEED, Detailed Design etc.) and implement the agreed changes
- Tests the designs against the lessons learned from previous incidents with the same type of plant and type of equipment
- Establishes the Basis of Safety throughout the design and can hand this in document form to the Operating Staff
- Applies the principles of Inherent Safety through the design phase (Minimisation, Substitution, Moderation, Simplification)
- Protective systems (SISs) are designed as per the international Standard IEC 61511 and test intervals derived from the LOPA/SIL analyses
- Design assumptions are recorded fully
- Human Factors are considered throughout the design phase (Layout, operability, alarm management, numbering systems, human error minimisation)
- Design audits are carried out (reviews, verifications etc.)
- Attention is paid to small items like O Rings which may be marginally unsafe (Challenger disaster)
- Where "state of the art" technology like advanced automation is used, ensure that it will work in practice. In a personal experience example, an advanced pneumatic conveying system for calcium ammonium nitrate was almost inoperable. Switching back to a standard conveyor and bucket elevator system restored the plant to acceptable availabilities.

Project Engineers

- Applies / participates in all the hazard studies in the project including the Pre-Start-Up Safety Review (PSSR)
- Freezes design / introduces a MOC System when HAZOP is complete
- Ensures BOS is not compromised when changes are introduced
- Ensures process safety is not compromised at any stage of the project because of the need to meet the project schedule and cost targets
- Ensures that the plant is built as per the design through system and physical checks
- Monitors and audits the construction work and commissioning activities performed by contractors and own staff
- Understands and applies the principles of process safety management

Site and senior management process safety behaviours

- Be knowledgeable about the major site risks and the safeguards for these risks
- Reviews the top 10 Process Safety site risks and continuously works on reducing these risks and the overall site risk profile
- Leads site Process Safety Management (PSM) audits and continuously improves the audit scores
- Are sceptical about ongoing "good news" audits
- Closely monitors the leading PSM indicators for the site and reacts rapidly to negative trends
- Ensures that there is an effective emergency response system and that the different emergency scenarios are practiced at least annually with external services
- Develops a positive safety culture by exhibiting strong leadership, installing and managing an effective process safety management system and learning from all types of incidents
- Have a "chronic sense of unease" and act on concerns
- Balances attention paid to Personal Safety and Process Safety
- Welcomes bad news as well as good news coming up the line
- Actively combats signs of a "blame culture".
- Ensures that reward systems recognise and promote Process Safety activities and performance
- Promotes (within reason) opposing views and people who challenge the Process Safety "status quo".
- Insists on incident investigations delivering root causes and appropriate corrective actions
- Designs organisation structures that have Process Safety (& safety in general) represented at the highest level
- Ensures proper risk assessments are done when cost cutting programmes are undertaken

Engineering decision making

Poor decision making in different functions and levels in a company is often the precursor to undesired process safety behaviours or lack of required action. Professor Andrew Hopkins has analysed the role of engineering decision making in the Deepwater Horizon disaster in 2010 (Ref.3). Aspects of the flawed decision making included:

- Taking commercial risks without realising Process Safety risks were being created
- Tunnel vision in groups of engineers leading to considering only one failure mode (well failure)
- Confirmation bias – leading to interpreting test results to suit desired result (well integrity test)
- Use of final preventative barrier (Blow Out Preventer) which has a 50% failure rate
- Consensus decision making (pressure on any dissention)
- Lack of awareness of the Process Safety risks
- Lack of any oversight of the engineering decision making which had serious major incident implications

These "design" decisions were made remotely from the actual oil rig, and, in some cases, months before the actual event. The question arises – "What is the actual undesired Process Safety behaviour"? Options include:

- Implementation of the decision
- Actual decision made
- The flawed decision making process
- The group process (tunnel vision etc.) which was flawed

As the decisions made were not overseen by any other body, then the action (behaviour) resulting (e.g. accepting the well pressure tests) followed automatically. Strictly speaking the decision could be considered an antecedent (Antecedent-Behaviour-Consequence or ABC model) or precursor to the actual behaviour. As there was no checking or review of the decision, the action (behaviour) and the decision can be considered as one so, for all practical purposes, the decision is the faulty Process Safety behaviour.

Perhaps the more important question to be asked is "What can be done to improve decision making in any aspect which could impact on process safety and the risk of major incidents"? In particular, can a behavioural auditing approach, as is used for Personal Safety, be applied to decision making"? If an experienced senior manager who is steeped in a good Process Safety culture could act as an observer, then the quality of decision making could be judged in terms of required standards. It is difficult to see a junior person, as willing and intelligent as he/she might be, performing such a role. The impact of engineering decisions such as in Deepwater Horizon, or concerning the "O Rings" in Challenger or switching off the refrigeration for the MIC tank at Bhopal requires an in-depth knowledge of the plant, its hazards and the role of safeguards. The decision options have then to be explored against the requirements of the organisation values and safety culture. This is not a simple task. Probably, a better approach is work on the company culture and bring in decision making, both group and individual, as an aspect that must follow certain principles based on the learning experiences of events like Deepwater Horizon.

Two personal examples of decision making illustrate the complexity of making sound engineering decisions.

Whilst running a calcium ammonium nitrate prilling plant, the prilling tower spray nozzles were regularly blocking up with large calcium carbonate particles. A stainless steel filter was designed to strain these particles out before prilling. No safety concerns were noted and the modification ran well for some weeks. However, an explosion occurred later in the filter with significant plant damage. The investigation showed that the filter was too efficient and filtered out oil particles (oil used to coat prills) and built up a dangerous level of oil in the filter which then reacted with the very hot ammonium nitrate. A case of "not knowing what you don't know"? The Process Safety culture was not well established (1970s) and no one sensed that this problem could occur. Unsafe Process Safety behaviour?

Whilst running a pyrites burning sulphuric acid plant also in the 1970's, I was in the control room when the main electric boiler feed water pump failed. The waste heat boiler could tolerate no water feed for less than a minute before the boiler water tubes would start melting at $1200^{O}C$. The standby diesel feed pump had to be started in that time. The operators / shift foreman did not react quickly and 1-2 minutes passed before the operators turned to me to decide. I instructed them to start up the standby pump knowing that there was a danger of a steam explosion in the boiler. We got away with it and kept the plant online. However, I had committed a violation in making the decision. I am still not sure I did the right thing. This was a risky Process Safety behaviour.

Process Safety Behaviours – Only One Aspect of Major Incidents

It is well accepted that major incidents have typically several root causes. The Root Cause determination process, if correctly done and drilling down to 5 levels, will normally show fundamental causes in equipment, systems and people aspects. The causal structure of a major event can therefore be complicated and a ProcessSsafety behaviour will only be part of the cause structure. Of course, it can be argued that people lie behind all aspects of design, operation and maintenance etc. but this is not very helpful in trying to prevent all root causes.

Even if all aspects of Process Safety behaviour can be improved and controlled, then it follows that there will still be other causes of major incidents that require attention with other approaches.

Safety Behaviours – Personal Safety versus Process Safety

A small number of similarities can be observed:

- Some behaviours lead <u>directly</u> to an accident (Personal Safety) or major incident (Process Safety). Virtually <u>all</u> Personal Safety behaviour deviations can cause an accident in a simple manner (e.g. being burnt by acid whilst not wearing PPE). A <u>minority</u> of Process Safety behaviours can <u>directly</u> cause a major incident (e.g. failure to respond to high level alarm or closing the wrong valve).
- Both types of behaviours are promoted by a strong positive safety culture. This is normally created by enlightened and committed senior management.
- Behaviour based modification programmes which have been very successful in Personal Safety improvement can be applied to the simpler, direct Process Safety behaviours as well (ABC model)
- Although the precursors to major accident incidents are different to Personal Safety triggers, the collection and analysis of basic data for some situations can be similar and, in both cases, can lead to the reduction in "the base" of the safety triangles. Examples could be analysis of reactions to alarms in a control room (Process Safety) and the wearing of the correct PPE for different jobs (Personal Safety).
- The behavioural failures can be generically the same i.e. deliberate actions or omissions (violations) and human errors because of lack of knowledge or failure to pay attention.

There are also many distinct differences:

- A single Personal Safety behaviour is often the cause of an accident. Major incidents (Process Safety) are usually the result of multiple root causes of which only one might be a Process Safety behaviour issue.
- Process Safety behaviour deviations can lead to incidents harming many people including offsite fatalities. Personal Safety behaviours normally impact on few people with the person committing the behavioural deviation often being the victim.
- The consequences of the Process Safety behaviour incident are often remote from the place where the behaviour occurred. Personal Safety incidents are usually close (physically) to the behavioural misdemeanour.
- Personal Safety hazards are often very visible and it is obvious what the behaviours are which could cause the harm to be realised (e.g. trip hazard and failure to step around the hazard). Process Safety Hazards are often hidden (in the pipe) and the linkage between a behaviour and the hazard is unseen (e.g. failure to carry out pipe wall thickness tests leading to a pipe rupture.
- The Process Safety behaviour which leads to a major disaster might have happened months before the event. An example would be an implemented change to a material of construction without using a MOC process. Personal safety incidents tend to happen immediately or very soon after the behavioural deviation. An example would be falling off a roof because of not wearing a harness.
- Major incidents are infrequent but Personal Safety accidents are frequent. This means that collecting data relevant to Process Safety is inherently more difficult.

Table 1 shows a comparison of the main features of the two types of safety behaviours.

Table 1 – Comparison of process safety behaviours and personal safety behaviours

Process Safety Behaviours	Personal Safety Behaviours
Mainly indirect links between behaviour and consequence	Direct link between behaviour and consequence
Minority suitable for behaviour modification programme	All suitable for a behaviour modification programme
Often occur well before consequence happens	Consequence follows behaviour quickly (normally)
The behaviour can take place away from the plant (offices)	Usually the behaviour and consequence are close
Often part of a multiple root cause structure for an event	Usually a single behaviour can cause the consequence
Can impact multiple people including offsite persons	Usually affects a single person
Hazards are often hidden – behaviour connection “hidden”	Hazards are usually visible – behaviour obvious

This leads to several implications:

- There is scope for behavioural based improvement programmes for a limited number of Process Safety behaviours – simple direct behaviours such as responses to alarms could be included
- Developing a safety culture which caters for high standards in both Personal Safety and Process Safety could lead to a high performing company
- The methodology, priority and experience gained in collecting deviations for the bottom of the Personal Safety triangle can be applied, in parts, to certain Process Safety behaviours.
- Can apply the knowledge and methodologies applied to various types of human failure (violations, human error) to the Process Safety behaviours as well as Personal Safety
- Methods are required to link the effects of a Process Safety behaviour deviation to the parts of a plant where the loss of containment and consequences will occur (HAZOP, Bowtie)
- Methods, logical and creative thinking are required to imagine and dimension the “hidden” effects within a plant following a Process Safety behaviour deviation.
- Methods need to be established to identify and deal with Process Safety behaviour deviations that might occur months before the consequence manifests itself
- As major accident events are very infrequent and possibly disastrous, emphasis must be placed on the precursors for such incidents as these will happen much more often and allow the entity to prevent the major event. This includes Process Safety behaviour deviations.

What are the boundaries of the Process Safety Behaviours Concept?

It is possible to consider almost all actions and decision making as having a link to major incidents and Process Safety. The discussion around the engineering decision making in the Deepwater Horizon disaster illustrates this. The major determinant of whether this is a useful idea is: does it lead to meaningful methods of improving and controlling these aspects?

All behaviours including Process Safety behaviours are driven by values and shared beliefs of the organisation and perhaps the organisational segment which is being considered (e.g. a Site). This is normally called the organisation or site culture and dictates behaviour in all aspects of work including safety work. The safety culture is a subset of the broader culture. Culture can be positive towards Process Safety or negative.

As behaviours are the visible manifestations of the “hidden” cultural features of values and beliefs, the behaviours are the easiest to identify and address. However, as discussed earlier in the article, process safety behaviours can be complex in that:

- They are only part of the major incident causal structure
- They can have happened months before the disaster becomes imminent
- The link from the behaviour to the event can be very indirect

Process Safety behaviours can therefore be very remote from the ultimate hazardous event and consequences. There is no obvious cut-off between trying to identify and control all possible Process Safety behaviours directly and employing other more general approaches to minimize behaviour deviations. These approaches include the use of systems like MOC and development of a sound safety culture.

It is possible to have “islands of excellence” where there is a good but limited Process Safety performance, however in the absence of a good positive culture with outstanding leadership, the islands are unlikely to survive long and extend their influence to the whole organisation. A sound safety culture ensures that behaviours are consistently correct when there are no controls or “observers” to pick up deviations. The culture makes it clear what is expected of everybody and helps people to make sound decisions when there may be a conflict of values / priorities.

The relationship between a Process Safety behaviour and the organisation culture is a mutually reinforcing one. A particular behaviour (or action) can be confirmed or rejected by consideration of whether it is consistent with safety culture norms or values. There is therefore no real cut-off between looking at specific Process Safety Behaviours alone or in the context of existing culture. Simple direct behaviours do not need a reference to a culture but complex "hidden" behaviours might be different. It requires a judgement call based on the specific behaviour in a specific context. In a real life example an oil refinery had to consider the consequences of using an inferior piping material for a naphtha stream containing a dilute acid aqueous component. Carbon steel was chosen for cost reasons. The company did not have an established safety culture and the decision was a short-term expedient. Pipelines only lasted for a few years before requiring replacement with stainless steel lines. The author investigated a major incident on this system where a jet fire resulted from a leak in the pipe. This major incident might have been avoided if the Process Safety culture was firmly in place and the "long view" taken.

Conclusions

From the discussion and examples given in the paper the following conclusions can be made:

1. Some simple Process Safety behaviours which are direct, are suitable for a behavioural observation programme. An example would be the response of a control room operator to an alarm. Lists can be composed from the examples in Section 3.
2. The philosophy of reducing the size of the base of the Process Safety triangle as per the Personal Safety triangle applies and is a good method of reducing major incidents. This would apply whether the base (lowest tier) is solely or partially composed of human errors.
3. It is debateable whether there will ever be agreed ratios linking the bottom tier of the Process Safety triangle to the top tier of major disaster. This is probably due to complexity of actions/behaviours/decisions that make up the bottom tier.
4. The lists in Section 3 can be used to evaluate positive Process Safety behaviour. The techniques that could be used include:
   - Behavioural observation and intervention
   - Checklists to be used on audits
   - Checklists for meetings
   - Input into safety culture surveys
5. The lists in Section 3 can be used in the form of guidelines / training input to the various functions and the management levels.
6. It is a good use of resources to improve the company safety culture by improving decision making by engineers and similar functions.
7. The specific negative group processes such as tunnel vision etc. should be used as teaching case studies in companies.
8. For all practical purposes decision making functions like engineering should understand that the decisions they make are Process Safety behaviours and can be directly linked to the major hazard risks of the operation.
9. Process Safety behaviours are only part of the root cause structure of major incidents. Other factors are management systems and equipment.
10. There are more differences than similarities between Process Safety behaviours and Personal Safety behaviours. Process Safety behaviours are characterised by:
    - often being indirectly linked to the major disaster event
    - usually taking place well before (weeks / months) the disaster event
    - taking place far away from the place where loss of containment occurs
    - usually occurring with other causal factors such as systems and equipment failures
11. The knowledge of human failures in the form of violations and human error applies equally to Process Safety and Personal Safety behaviours
12. There is no obvious cut-off between considering Process Safety behaviours alone and considering the broader safety culture of the unit / company. Where the Process Safety behaviours are very indirect, separated in time and physical space from the resulting hazard event, then a good Process Safety culture can ensure that the best risk decisions (and resulting action/behaviour) will be taken. The Deepwater Horizon engineering decisions fall into this category.

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