

Why Human Error matters more than non-compliance in the major hazard sector a*nd why the sector still talks much more about non-compliance: a case study and the research*

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It is normally accepted that in the more mature major hazard industries – such as aviation, air traffic control, nuclear – the primary risks are from human error. While there is clearly a gradient across the sector e.g. in air traffic control error is predominant in incidents (figures of 95-99% figures are often quoted e.g. 98% in (Lardner & Maitland 2009, p541), this is still true for the chemical and allied major hazard sectors. This can be illustrated by many major incident case studies e.g. Buncefield, Texas City, Longford, where the initial focus on apparent frontline non-compliances was later shown by more detailed investigation to be largely error-driven – the operators were set up to fail.

Where error is thought to be a key issue, a good investigation will look for those performance shaping factors (PSFs) which made the error(s) more likely on the day. So it makes more sense to look in advance for these PSFs so that the sub-optimal ones can be fixed before something happens – or at least before near misses turn into real losses. It also provides an assurance mechanism for the PSFs that are already optimised, to make sure they stay that way. In effect this is an error audit approach looking for just those error-producing factors resulting from latent conditions (Reason 1997) which lead to error and non-compliance.

This paper covers one anonymised prospective case study in a large organisation where far-sighted management recognised that, despite the historical heavier focus on non-compliance generally at the site, error was likely the real problem. Specifically there was an increasing history of valve misalignment errors and tank / pipeline line-up incidents in the central facility charged with managing highly flammable and other hazardous bulk movements in and out of the main process operating units. The author was asked to design and deliver an intervention to review current vulnerabilities to human failure in these activities, focusing on human error. A sample of incident reports was analysed before the site visit to look for any existing hot-spots or patterns. The key occupational groups involved were sampled through workshops, interviews and walk / talk-throughs using a PSF framework (from those used in the Human Factors Analysis Tools (HFAT ®) (Lardner & Scaife 2006) investigation method) as a prospective tool to elicit key issues and also, importantly, possible solutions. A range of supporting interviews and additional site visits were also carried out.

The results were then prioritised by weighting within and between groups, and mapped between groups and by PSF category. Expert opinion was then used to help finalise priorities. The project successfully identified a wide range of PSFs indicating that the likelihood of error – and error resulting in a significant loss of containment – was high. The priorities and key issues were identified for leadership action on the improvement strategy and to target resourcing more effectively. Recommendations are also made for wider adoption by the chemical and allied major hazard industries of this prospective error audit or screening approach.

Keywords: Human error, valve misalignment, performance shaping factors, non-compliance, workaround, violation, error audit

What behaviour?

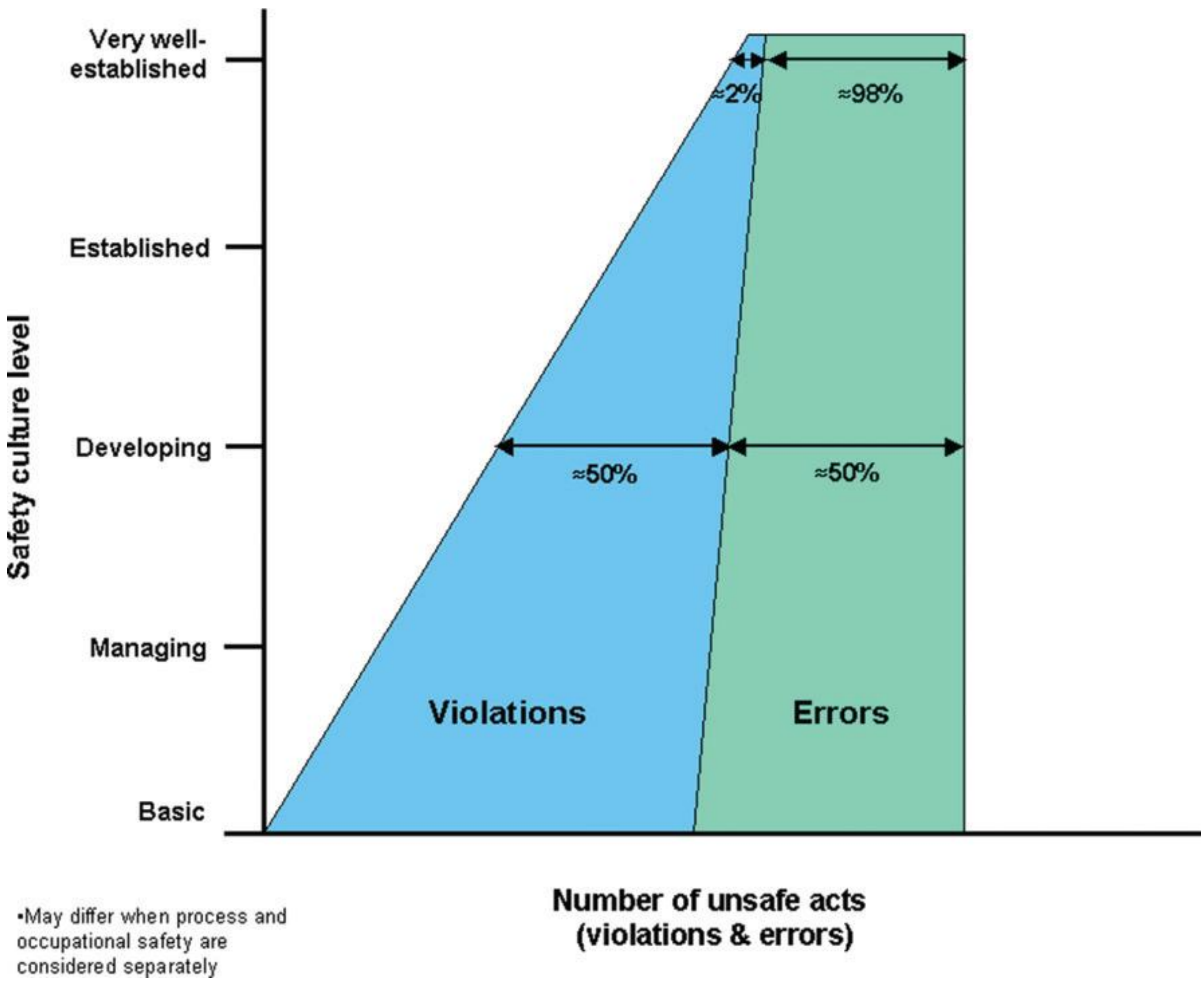
The author's experience as a regulator, human and organisational (HOF) professional and consultant has led him to question why the high hazard process industries generally discuss and debate non-compliance (this term is used throughout but is interchangeable with 'violation' or 'workaround') as if it is their primary concern. This can lead to an over-focus on the apparent non-compliance through behavioural programmes and culture initiatives when the underlying real issues – as evidenced by the investigated incidents and accidents, including major accidents - show that human error is more dominant. This is not to say that an appropriate behavioural or safety culture approach is wrong of course, in practice they and an effective error management approach are both likely to be needed but it is about getting the balance right. And while there are examples of behavioural safety / safety culture programmes which properly embrace process safety, error-producing conditions and key supervisory and management risk control behaviours, they are admittedly uncommon.

To put it another way, the unsafe conditions created by poor error management far outweigh the unsafe behaviours as root or contributory causes to incidents. In using 'human error' as a term this is used to cover not just the immediate and frontline errors but also the latent conditions (Reason 1997 p10) often created by organisational factors – such as resourcing decisions, workload and planning and so on – that then create the circumstances in which error (and non-compliance) are more likely to occur over time. As James Reason has pointed out: '…active failures are like mosquitoes. They can be swatted one by one, but they still keep coming. The best remedies are to create more effective defenses and to drain the swamps in which they breed. The swamps, in this case, are the ever-present latent conditions.' (Reason 2000,). So frontline errors are a consequence usually and not a cause. And non-compliance usually leads to errors as the immediate precursor to a release – no one sets out to have an accident.

Of course this is hard to quantify but generally if the more mature high hazard industries are considered then e.g. air traffic control (ATC) incidents are very largely error-driven – as one might expect and hope, though the data is hard to come to come by because of the difficulty in untangling 'human error' as cause and consequence from the latent conditions. The process industries while not yet so mature as ATC, wider aviation or the nuclear sectors nevertheless tend more towards this category than say, construction or other mainstream industrial activities. It is no accident that James Reason for example uses the words 'error-producing" to describe the factors created by the latent conditions. (Reason 1997; p 10). This point is reinforced by standard human factor textbooks e.g. a very recent one on HOF in design states "Industry underestimates the extent to which behaviour at work is influenced by the design of the working environment." (McLeod 2015).

The figure below illustrates the balance between non-compliance and error as against safety culture maturity level. As the authors point out "There is a perception amongst some managers and engineers that with good training and processes, errors are unlikely to occur – which is not the case…human error…often involv(es) the most competent and experienced personnel… (so) it is puzzling why some organisations are reluctant to tackle human error, thus hindering the development of a learning culture, and missing important implications for personal and process safety.", ((Lardner & Maitland 2009, p540 emphasis added; and see HSE 1999 p13-14 where the same points are made). So the real issue is how to tackle error i.e. to establish effective arrangements to prevent, detect and aid recovery from error.

Figure 1: Safety culture level* vs. unsafe behaviour



This finding is supported by emerging evidence from other high hazard sectors such as health care e.g. a recent large-scale occupational psychology review on supporting healthcare culture change (following the Francis report into the Mid Staffordshire Hospital events) notes in the executive summary that "Work design should be regarded as fundamental to improving care quality... Aspects of work design include the physical layout of wards, which where possible should enhance patient safety by allowing a clear 'line of sight' to all patients." (British Psychological Society 2014, p3). Work design done with proper consideration of HOF is simply error management for existing work and essential for new design where all system users are considered and a human-centred approach is taken to eliminate or minimise the potential for error.

In large part the above problem of over-focus on non-compliance can be explained by one of psychology's more robust findings – the Fundamental Attribution Error (FAE) (e.g. Reason 1997 p126-7; and 2013 p86). This is our natural tendency (our inbuilt cognitive bias) to overestimate another individual's personal contribution to an incident and to underestimate the likely impact of external, environmental and related (including organisational) factors. Whereas of course we do the reverse when seeking to explain (or excuse) our own behaviour. This bias probably had some evolutionary advantage but this is now outweighed by the increasingly complex and changing world we inhabit, and no more so than when we are at work.

And while we can adjust for this bias in normal life it takes considerative time to do so, time that we do not always have. This is why good investigation requires appropriate and structured consideration of HOF so that this bias is offset by thorough consideration of all of these factors. In the same way, the process industries tend to focus on the more personal non-compliance aspects of behaviour immediately rather than necessarily seeking out the wider job and organisational factors – or at least not seeking them out so well.

So of the two behaviour categories that exist, that of non-compliance is the one most often talked about by aggrieved managers, safety professionals and supervisors. But the underlying causes of this behaviour are most often due to poor (unstructured or non-human-centred) design, hazard / risk analysis and operating / maintenance arrangements. This is illustrated by this author's preferred transatlantic term of 'workarounds' because it nicely describes the real reason for the undesired behaviour i.e. to get around sub-optimal equipment, tools, plant, processes, task, job and other designs and arrangements. And it underlines that in most cases people are simply trying to get the job done as best they can in the less-than-ideal circumstances they often find themselves in – this is 'work as done' as opposed to 'work as imagined' (Hollnagel 2014). It is very rare that people are deliberately setting out to cause damage or have an accident.

This is the point that Eric Hollnagel among others has been putting forcefully in recent years (e.g. see Hollnagel 2014 for a recent and accessible account) in reconsidering the existing traditional safety paradigm and refocusing attention towards what goes right and not just on what goes wrong, the traditional safety focus. He shows that behaviour is more an expression of our innate human variability. We adjust our performance in line with the conditions we find ourselves in at work and we do this to make things work i.e. to succeed in what is an increasingly complex, and often resource-constrained organisational environment beset by competing goals. This human performance variability therefore creates failure ("unsafe acts') but is also responsible – and much, much more often – for our successful work outcomes. Accidents are relatively rare occurrences (and major accident even rarer) and most of the time the work gets done. So, rather than just focusing on surface compliance issues, we need to step back and help people adjust better to their environment. And that means a balancing focus on error, and preferably error management i.e. setting people up to succeed, not fail.

An engineer might be tempted to argue against this and argue instead for increased automation (taking the human 'out of the loop'). However, with the increasing reliability of engineering and technical measures and of processes, the focus shifts further towards considering human variability and with automation this variability is less tractable because reliance on people still remains in such system e.g. to maintain, inspect and test; and to monitor and where necessary intervene at short notice in the control of the process.in the process. Errors become less predictable in these systems. Designers do not – and cannot – have 20-20 foresight so this will always be the case.

While a focus on behavioural and culture is also appropriate, neither can gain much purchase if the potential for human error is not managed. Behaviour-based safety (BBS) is also generally not a good fit for process – as opposed to occupational – safety (e.g. Anderson 2004). And while typically both BBS and safety culture initiatives should take appropriate account of prevailing workplace and organisational issues when being set up, they typically do not take a sufficiently structured approach to error management - except for more recent approaches such as behaviour standards' frameworks if organisations pursue their initial involvement findings robustly.

So this leads to two conclusions: that more focus is needed on error and error management; and that for existing processes this should be a structured part of ongoing audit and review arrangements. It also provides an assurance mechanism for the PSFs that are already optimised, to make sure they stay that way. This approach reflects the proper 'chronic unease' necessary for a high hazard organisation. The following case study illustrates how a prospective error screening tool was developed and deployed at a central department on a complex high hazard process site.

An example of Applying a Prospective Error Screening Approach

Background and method summary

This project was carried out for a major global company operating a large processing site. The main driver was an increasing history of valve misalignment errors and incidents in setting up and carrying planned bulk movements of hazardous (mainly flammable) liquid material. Typically these were 'line-up' errors in the work of the central department charged with this work. The main occupational groups involved were sampled through workshops, interviews and walk / talk-throughs using a performance shaping factors (PSF) framework to elicit key issues. In effect the same process used in a good investigation – where identifying 'human error' is just the starting point for further and deeper investigation – was adapted for use prospectively, and in a structured way that involved the department staff representatively at all levels. The screening tool was used in a way that provided some 'triangulation' of evidence e.g. between documentation, incident / error history, ongoing site audit and review, and the reality on plant. The client finally elected to remain anonymous so some of the detailed findings have not been shared here where they might help identify the company..

Project Background

The requirement for this project was to review current vulnerabilities to human failure (errors and non-compliance) through valve misalignment at one department within a large processing complex. A phased approach was taken. The objectives were:

- To gain a higher-level understanding of line-up tasks and processes.
- To identify current issues, concerns and potential solutions from those involved.

- To understand the background through previous incidents and current improvement plans.
- To understand the scale and other specific features of the problem at the site / complex.

The main scope was tank and pipe line-ups for raw materials, intermediate and final products with potential for significant health, safety and environment incidents. Although tank overfill was one common outcome there were others e.g. accidental product mixing. In reviewing vulnerabilities, account was taken of current improvement plans following previous incidents. The project outcome was designed to provide a clear set of recommendations and priorities to address the vulnerabilities and to assess current improvement plans for this.

The focus was intended to be on the HOF issues rather than the technical and engineering measures which are well covered elsewhere e.g. there are very detailed UK requirements for similar operations available post-Buncefield and of course also others. The post-Buncefield reports also include specific human and organisational factor issues (HSE 2009) and these were reviewed as part of the preparation for the project and site visit.

Project Design

Despite the apparent (surface) visibility of non-compliance in incidents, the view of the department's new leadership team was that the underlying causes of valve misalignment were most likely to be human error. The site also used a detailed HOF approach to selected investigations (HFAT®); Lardner & Scaife 2006) and this helped inform their view by identifying specific errors. The recognised absence of specific line-up procedures or other job aids also made tackling non-compliance directly very difficult in practice e.g. in the absence of reconsider and consistent benchmarks (standards, guidance etc.) it is hard to reliably and fairly identify non-compliance .

The main project focus was therefore on the line-up task and on human error as the main behaviour of interest. Non-compliance could still be identified where there was evidence, but as noted above, without a clear written system and procedures for transfers and line-ups this would be hard to show clearly. If the performance factors that shape or influence performance (Performance Shaping Factors or PSFs) – and therefore the likelihood of error – are identified and tackled, the apparent non-compliances often reduce because of this and any remaining ones can be more easily addressed.

Overall the project was designed as an audit / inspection approach based on similar interventions by the Health and Safety Executive (HSE), the UK regulator for similar high hazard sites and processes. The approach provides some structured triangulation between people, documents / arrangements (including the incident / error history), ongoing audit and review, and the reality on plant. The relatively short but intensive site schedule also reflected this approach.

Incident analysis, gap analysis and background information

A sample of relevant incidents was requested for assessment from incident reports to (a) allow the consultant to become familiar with these and the background before visiting site; and (b) look for patterns and previous solution attempts. A sample of five well-investigated incidents was suggested. The sample was selected by department management based on what was available in the main incident reporting database, and included 5 substantive investigation reports of significant incidents over the last 3-4 years. There were 13 incidents in total in the sample provided. The key finding from this analysis was that it confirmed that human error predominated as root or contributory cause(s) and that a wide range of PSFs were involved.

The analyses and other preparation – including sight of key documents e.g. for planning - were used to develop the site visit agenda, questions and prompts for the site workshops and interviews, and to help identify areas for walk / talk-through. A gap analysis tool for good practice (focused on the human and organisational factors) was also developed at this stage. This information was also used to help prepare prompt questions for the workshops and interviews.

Workshops and interviews

A series of short workshops were designed for the key personnel and occupation groups affected i.e. Managers, Supervisors, Workforce those involved in generating and planning raw material, intermediate and product movements and transfers. The later were a small central planning unit.

The intent of the workshops was to surface and capture current attitudes and behaviours, concerns, specific issues (real and perceived), and also solutions - those people directly involved in tasks usually have good ideas about how to fix things. The opportunity was also be taken to introduce attendees and interviewees to some basic human facts about error and non-compliance (with respect to line-ups) so that this would support and inform their subsequent participation and contribution.

The workshops were supplemented by selected interviews e.g. with the department's process engineers, where necessary including relevant union and safety representatives. The selection was agreed after document / incident review and discussion between the consultant and the leadership team. The workshop and interviews also offered an opportunity to further align expectations with the workforce and to further underline management intent and focus on the line-up and overfill issue.

The workshops were structured round the set of PSFs used in the Human Factors Analysis Tools (HFAT® (Lardner & Scaife 2006) investigation process for human error. The PSFs were used at a category level (Table 1 below) to help structure the interviews, along with the prompt questions. There are eight categories:

Table 1: Performance Shaping Factors (PSFs) by Category

PSF Categories
1. Task Factors
2. Communications Factors
3. Procedures and Documentation
4. Ambient Environment
5. Training and Experience
6. Human-Machine Interaction
7. Personal Factors
8. Social and Team Factors

The full set of PSFs provided a framework to facilitate structured discussion, with attendees selecting key PSFs from the list, including those that worked well and improvement suggestions. The corresponding issue were briefly noted alongside this, and any suggested solutions explored and recorded. Some prompt questions were also developed based on the background documents and incidents provided, and on relevant other incidents such as Buncefield.

Four workshops were planned and carried out. Attendees were selected by department management based on availability and experience so this was part opportunistic and part client-selected. The sample was as large as was feasible for field staff given the prevalent shift system issues. Attendees were all shown the same short introductory PowerPoint presentation which (a) Introduced the project background, purpose, objectives and scope; (b) Assured anonymity and confidentiality; (c) Gave an overview of what HOF is for the high hazard industries; and (d) Introduced the two main behaviour types – non-compliance and error – and the role of PSFs in making error more or less likely. Attendees were then taken through the PSFs using copies of the standard HFAT® PSF glossary for reference where necessary to aid understanding and ensure consistency.

To provide transparency and build trust the attendee comments and issues were recorded onto the worksheets while projected onto a screen in the room. Attendees were therefore able to verify that the notes were accurate and conveyed the substance – and where possible the actual words - of what was said.

Walk-talk-through (W/T-T) of selected line-ups

A walk / talk-through (W/T-T) of selected line-ups with operators and relevant others was scheduled and carried out on plant as part of the site visit. This followed the workshops, interviews and familiarisation. Attendees helped select the most representative tasks for this. A W/T-T is a key part of understanding any task e.g. in classical task analysis. Although this was not designed to be a full high-level task analysis it was intended to follow the line-up process through from start to finish so far as possible. This would produce first-hand information to confirm what was found in the workshops and interviews, and to act as a reality check. It also provided further scope to identify current processes and practice with a view to prioritising any further improvements to minimise the likelihood of further errors or non-compliance on critical tasks. This information would also help in supporting the development of suitable job aids and other measures. The central and local control rooms in the relevant areas were also visited so that a fuller picture could be gained e.g. for communications arrangements and information availability.

Workshop and interview results

There was full consensus that human error was the proper main focus for the project although the planning / scheduling results did show a stronger view on non-compliances as well. An extract of the overall results are presented in Table 2 below. This is helpful at a headline level - a further breakdown was provided for each category as well in the main project report. Each salient PSF was reported against and prioritised; and specific improvement recommendations were given to the client as well as a summary of all staff improvement suggestions, and consultant-generated ones.

The first four columns report on the four workshops. The next three (far right columns) show the results from the process engineers' interviews, the central control room visit and discussion, and the W/T-Ts. The latter are allocated under the PSF framework for comparison. They have not been highlighted because time did not permit a full PSF screening; however the results can be readily mapped across. The specific issues were captured elsewhere and the key ones are reported back on in the conclusions and recommendations' section below.

The overall results were prioritised by weighting within and between groups, and mapped between groups and by PSF category. Expert opinion was then used to help finalise priorities. At the headline level it is possible simply to say that a very wide range of adverse PSFs were identified across the categories, indicating that the likelihood of error was confirmed as high. The incident / error history and ongoing audit / review findings supported this. Seen against these PSF findings, the department staff appeared to have managed the error level remarkably well until recently given the inappropriate level of reliance on manual operations and other key factors which potentially impacted performance. It is also noteworthy that a good range of the potential solutions were suggested by staff themselves, at all levels.

Table 2: Extracts from the summary of negative PSFs identified as issues at the Workshops, Walk / Talk-throughs and Interviews *(Note: example PSFs given focusing on the most frequently-occurring ones)*

Key: Red: identified in all four workshops; Amber: identified in three out of four workshops; Yellow: identified in two out of four workshops

List of Performance Shaping Factors	'x' indicates this PSF was identified as relevant in that workshop, interview or activity						
	Workshops				Activities, interviews, observation		
1. Task Factors	Management	Supervisors	Field Operators	Planners	Walk / Talk-throughs	Process Engineers	Control room Operators
1.1 Number of tasks	x	x	x	x	x	x	x
1.2 Complexity of tasks	x	x	x	x	x	x	x
1.3 Time pressure	x	(x)	x	x	x		x
1.4 Workload not due to task	x		x		x		x
1.5 Non-standard activities	x		x		x		
2. Communications Factors							
2.1 Communications workload	x		x		x	x	x
2.6 Communication quality	x		x		x	x	x
3. Procedures and Documentation							
3.1 Procedure availability/access/location	x	(x)	x	x	x	x	x
3.3 Procedure accuracy/correctness	x		x		x	x	x
3.4 Procedure comprehensiveness or completeness	x		x		x	x	
4. Ambient Environment							
4.1 Weather	x	x	x	x	x	x	x
4.3 Lighting	x	x	x	x	x		x
5. Training and Experience							
5.1 Familiarity with task		x					
5.2 Level of experience	x	x	x	x	x	x	x

5.3 Time on job							
5.4 Availability of training	x	x	x	x	x	x	x
6. Human-Machine Interaction							
6.3 Information availability/access	x	(x)	(x)	(x)	x	x	x
6.11 Equipment reliability	x	x	x	x	x	x	x
6.12 Trust in equipment	x	x	x		x	x	x
6.14 Allocation of tasks between person and systems	(x)	x	(x)	x	x	x	x
7. Personal Factors							
7.1 Alertness / concentration / fatigue	x	x	x	x	x	x	x
7.7 Job satisfaction/morale	x	x	x		x	x	x
8. Social and Team Factors							
8.4 Handover/take-over		x		x	x	x	x
8.6 Team relations and trust	x			x	x		
8.10 Shift organisation	x	x	x	(x)	x	x	
8.11 Supervision	x	x		x		x	
8.15 Staff availability	x	x	(x)	x	x	x	

Conclusions and Discussion

The primary issue emerging from the analysis was that the shift system for the control room and outside operators was the key and immediate issue to be resolved and that this was primarily a leadership issue. There was also a very clear process safety issue for the site as shown by:

(a) The incident history and evidence of recent increases in incidents and errors attributed to valve misalignments;
(b) An inappropriate and unassessed reliance for line-ups on manual operations to achieve process safety without a clear automation strategy;
(c) Clear evidence of widespread and substantial unresolved negative PSFs likely to induce human error; and
(d) Clear evidence of the shift system problems as the key issue from the workshop, interview results across the main occupational groups involved, and expert opinion.

The top five issues identified at the initial feedback to the leadership team on the final day of the project site visit were:

1) Chronic and unresolved shift system issues including unsustainable levels of individual overtime for safety critical roles.
2) A lack of strategic focus for the department in question.
3) Over-flexibility in, and lack of agreed ways of carrying out, line-ups.
4) Lack of focus and resource for training, updating materials, procedures etc.
5) Culture issues e.g. evidence of widespread 'learned helplessness'; low morale and a shared sense of being undervalued; and a focus on non-compliance and sanctions without a corresponding balance e.g. by recognising achievements.

The key to resolving these issues was identified as a quick and effective leadership response to address the chronic shift system issues and to re-establish a stable and predictable shift system in the department concerned as soon as possible. Once this could be achieved the effectiveness and e.g. staffing of the existing shift system could be addressed and this in turn would provide a secure basis for dealing with training, procedural and line-up issues. All of this required a robust approach to a long-standing history of e.g. frequent call-offs, often at short notice, by a significant proportion of those employed on shift. The underlying causes of this were seen by the department (and also corporately) as unresolvable, at least in the short term.

This situation had produced a very clear conflict with the organisation's otherwise strong commitment to process safety, and occupational health and safety, a commitment explicitly shared by management, workforce and unions level. There were striking parallels in the current situation to those found through investigation to be prevailing prior to the UK Buncefield major accident in 2005 (HSE 2011). The issue of strategic focus was also vital – the department's role within the site complex is relatively unique and so warranted a discrete strategic focus within the overall business and safety strategy.

Without leadership commitment and action the wider cultural issues were unlikely to be resolved. Previous initiatives had foundered for similar reasons. A lack of leadership action would simply have reinforced the evident 'learned helplessness' in the department and defeated any other improvement plans however well-intentioned. However, there was a quick and effective leadership response which showed real commitment, building on that demonstrated by the project itself.

There were significant positive findings from the project as well e.g. that the leadership team was demonstrably keen to engage with HOF issues and recognised the need for this; the evident commitment and persistence under pressure of the department's workforce; the presence of a relatively new and active management team in the department; and ongoing plans to reposition and rebrand the department within the site complex.

The conclusions from the analysis for the five headline issues are briefly described in the sections below.

Shift system issues

The current shift system was not being worked as planned and was subject to unpredictable and frequent short-notice call-ins. A significant proportion of those on-shift (up to a quarter) were subject to a unique national legislatory requirement enabling them to call off at short notice. There was consequently extended overtime, and lack of stability to allow staffing adequacy to be properly assessed, or to train, revise training materials or develop procedures and allied job aids.

The predictability of a shift system (both for individuals working the system and for those managing and supervising this) is a key element of good shift schedule design and operation (Miller 2006) and to some extent compensates for the less social aspects. This is lost when a shift system does not work as planned. Equally, acute and chronic fatigue was reported as present among a significant number of staff from the extensive and poorly distributed overtime. Working while fatigued has been compared to being under the influence of alcohol and can result in so-called 'stupid' behaviours i.e. gross errors (Miller 2006). The shift system not working as planned also distracted supervisors and others from their main roles, affected morale, was inefficient and led in turn to more errors. Without stability the necessary training and procedure improvement work could not get going.

But just providing extra people to fill gaps would not have addressed these issues without first tackling the root cause. Prior to the project this had been widely seen as outside the site's control. However, the project results together with the organisation's and site's process safety commitment enabled this to be addressed e.g. the project results underlined the striking parallels with the situation found to be prevailing prior to the UK Buncefield incident. This helped empower the departmental and site leadership teams to act.

Lack of strategic focus

The legacy situation found in the department indicated a lack of strategic focus for the department. A mix of factors was present such as lack of investment and strategic direction for plant and equipment including tank storage, and automation / instrumentation. The department was therefore constantly working around bottlenecks and inadequate service, transport, maintenance and other central provision designed more for the main complex processing operations than for the department's more central facilitative role.

Over-Flexibility and Lack of Agreed Methods for Line-ups

The situation as found was a recipe for error as shown by incidents and the long list of significant and unaddressed PSFs. The demand for novel line-ups (in effect 'workarounds' on a job-by-job basis) had been steadily increasing but while this brought short-term flexibility and advantage it created a nightmare situation for longer-term error management. This over-flexibility for line-ups without concomitant systematic automation / instrumentation arrangements matched to process safety and business needs was an increasing source of errors and incidents. Poor communications between central planning and the department made the situation worse as the department tried to respond to increasing demands for flexibility without the necessary plant and equipment investment and changes to enable these.

There was a corresponding lack of agreed and assessed ways of lining up. All of this, coupled with poor proceduralisation and the absence of job / task / error assurance aids was simply a recipe for error. The remarkable thing was really that the errors had not so far resulted in more incidents with serious consequences. This could in part have been because of the department staff's dedication and persistence despite the issues affecting their performance. The situation was made worse by the loss of experience and loss of corporate memory because departing experience was not routinely captured into procedures and training guides. Workforce turnover, retention and related issues made this worse. Low morale and perceived undervaluing of the department made it an unattractive place to work and this affected recruitment and retention.

Training focus

There was good but very limited training support for the department and the availability of even this resource was in turn significantly reduced by pressures to populate the shift system e.g. by use of trainers. The lack of training focus also impacted training materials, procedure and training guide updating, and job aid improvement opportunities. Achieving the desired better operating discipline required a solid, up-to-date and fully available training and competency baseline from which to start, and a suite of owned and valued critical job / task /error assurance aids and detailed related performance standards for on-the-job training and assessment. There were also opportunities for rolling out cross-training more widely for the department to improve staffing flexibility when the shift system issues were addressed. This was a bottleneck along with training and procedure updates.

Culture

There was good evidence of 'Learned helplessness' (see below) and low morale in the department and this appears to have been declining for some time. There was a general and pervasive sense among staff that their work and role within the complex was undervalued. Staff were also increasingly innovating in difficult circumstances e.g. chronic lack of resource for operations staffing and for maintenance support; made worse by turnover, retention and shift system issues. A more balanced approach to human error was also required for behavioural improvement and morale which took account of the full range of PSFs i.e. not just personal factors but job and organisational ones, and placed at least equal weight on positives such as reward, recognition and other positive reinforcement for the behaviours actually wanted, and not just on the necessary sanctions and disciplinary measures.

Learned helplessness

This was originally defined as a mental state from animal behaviour experiments which followed up on B F Skinner's seminal behavioural studies. It was subsequently developed and applied to people (Seligman 1972). "Learned helplessness occurs when an animal is repeatedly subjected to an aversive stimulus that it cannot escape. Eventually, the animal will stop trying to avoid the stimulus and behave as if it is utterly helpless to change the situation. Even when opportunities to escape are presented, this learned helplessness will prevent any action.' (Cherry 2015). The typical image shown in psychology textbooks is of a dog shivering helplessly on an electrified laboratory floor after being subjected to a series of (for it) unpredictable and apparently random shocks.

This concept can be extrapolated to a group of individuals as e.g. represented by a part of an organisation, given that this consists of individuals learning together or separately from similar adverse stimuli over time (e.g. Ashkenas 2012). In this case the apparently intractable underlying organisational issues such as the shift staff call-offs – which were the adverse stimuli. The department was in effect left helpless by these repeated and unaddressed 'shocks' with consequent serious impacts on morale and increasing passivity in terms of trying to solve the issue.

The site response

The site and department concerned have responded quickly and effectively to the project findings and this is work in progress for them. The new department leadership team had signalled their intent clearly by setting up and delivering the project, and the findings supported their bids to structure, prioritise and fund their already-developing improvement plans. As is so often the case for consultancy and the regulator, at a high level the intervention simply held up a mirror to the site but with the addition of structure, solutions, and a clear basis for prioritisation. In this case the mirror was held up before a major incident drew the site's attention much more forcefully to the underlying organisational and error management issues.

Further use of the error screening approach

The use of the error screening approach worked very well in providing an appropriate structure for the project and the findings. It would be a very useful prospective audit tool for any high hazard site and can be readily adapted to specific site circumstances and needs. After all, why wait till the errors result in a significant incident or accident when you can identify them and address them earlier in this way, and can involve staff at all levels in doing so. There are lists of PSFs available to use freely but they will likely need some tailoring for an effective prospective screening. They will certainly need to be facilitated by someone with sufficient understanding and knowledge to draw the issues out reliably. This doesn't just mean sufficient HOF knowledge and experience – for hazards - but also process experience though the two don't necessarily need to be vested in one person. A good starting point would be to identify someone who can reliably identify PSFs in an investigation. That's where the author would start anyway.

The 'wallpaper' and managing for success

In the case of this project, the leadership team had recognised that the initial apparent non-compliance issues were in fact masking the underlying error-producing factors resulting from the latent conditions present at site, and particularly the organisational factors – the 'wallpaper' i.e. 'The way things are round here' (Wilkinson and Rycraft 2014). This paper therefore has argued strongly for the more mature high hazard industries to focus at least equally on the underlying error management issues as well as the surface non-compliance or workarounds. This means paying more attention to human factors in design, hazard / risk analysis and operating / maintenance arrangements, as well as identifying and addressing those more difficult organisational factors.

This project also underlines that people are remarkably successful most of the time at making things work despite the prevalent negative PSFs – but when 'making things work' becomes 'workarounds' which affect safety they will sooner or later result in loss of containment with varying consequences. What any successful high hazard business wants is to harness their people power for business success – such as through innovation, creativity and simply making things work well – without losing control through unmanaged workarounds where safety is compromised. But just putting more rules and procedures in place won't do this as it also kills off that people power contribution. So managing error through good design and other processes allows businesses to focus on what matters, reduces the level of errors (and so of non-compliance), benefit from what people do well (which they do most of the time) and lead on to a smoother-running, more efficient and profitable process and enterprise.

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