

Creeping Changes

Richard J. Goff, Jill Wilday and Justin Holroyd
Health and Safety Laboratory, Buxton, UK

The issue of creeping change was highlighted by the Health and Safety Executive's (HSE) Key Programme 4 (KP4) which investigated Ageing and Life Extension in the offshore oil and gas industry as an important issue to address when managing ageing assets. Creeping changes can have potentially catastrophic effects on both major hazard safety and production, and have contributed to several major accidents such as the Nimrod loss.

Creeping change covers a range of changes in equipment integrity, reservoir and production conditions, and human factors and organisational culture. As the name suggests, creeping changes are those that occur gradually and slip under the radar of processes to identify and manage hazards.

- A toolkit to address creeping changes would include:
- a methodology for identification of creeping changes
- periodic reviews/ audits by a 'fresh pair of eyes'
- monitoring changes and taking appropriate and timely decisions to prevent failures
- awareness and prevention of procedural drift
- moving towards a culture of mindfulness including mindful leadership
- embedding high reliability organisation (HRO) principles within the organisational culture

1 Introduction

The Health and Safety Executive's (HSE) Key Programme 4 (KP4) on Ageing and Life Extension in the offshore oil and gas industry, to which the Health and Safety Laboratory (HSL) contributed significantly, found that there were insufficient systems to deal with creeping changes (HSE, 2014). Creeping changes are a safety risk that has only relatively recently been highlighted as a significant issue.

Creeping change is the accumulation of small changes which often go unnoticed, but can add up to a significant change, but because of their gradual nature no hazard identification study or risk assessment has been performed. They are gradual, unseen and not planned, and because of this can be difficult to monitor (as an example, the increase in the number of fuel leaks on the Nimrod aircraft that exploded over Afghanistan was not noticed (see section 2.1)).

While the effects of creeping changes are relatively uncommon, they are rarely trivial and can be devastating (see later for the role of creeping changes in some major accidents). As well as major accidents, creeping changes can cause major equipment failure (having potentially both safety and production implications). It is widely recognised that controlling safety by effective asset management means reducing failures and downtime, and so is key to increasing production efficiency. Creeping changes will become ever more prevalent if not checked and addressed as industrial assets age. If equipment is failing regularly then it will not be available for production and will inevitably increase safety risks. Data trending will be key to monitoring creeping changes and preventing equipment outages, but first creeping changes need to be identified before they can be monitored.

The information in this paper is derived from three sources. Firstly, HSL supported HSE during KP4 and KP3 (Asset Integrity programme) in analysing the inspection data that were produced as part of these programmes. HSL have hosted post-KP4 workshops for the oil and gas industry, the topics of these workshops included creeping changes, development of leading KPIs and data trending (see also Chambers, 2015). Finally, HSL has extensive experience from across all the major hazard industries in which it works and is in a unique position to draw together themes, and transfer learning from one industry to another. This experience includes previous work on the principles of so-called high reliability organisations (HROs) (Lekka, 2011). HRO principles are intended to improve resilience to the precursors of major accidents and include an attitude of constant unease about the potential for failure.

2 The role of creeping changes in major accidents

2.1 Nimrod

On 2 September 2006 an RAF Nimrod MR2 was lost over Afghanistan killing 14 service personnel on board. The subsequent investigation found that a fuel leak or overflow after air-to-air refuelling caught fire causing the aircraft to explode.

An independent review into the causes was led by Charles Hadden-Cave (H-C) QC (Hadden-Cave, 2009) found numerous contributory factors including:

- "a Safety Case regime which is ineffective and wasteful;
- an inadequate appreciation of the needs of the Aged Aircraft;

- a series of weakness in the area of Personnel;
- a Safety Culture that has allowed 'business' to eclipse Airworthiness."

The H-C Review also found 12 parallels with the loss of the NASA Space Shuttle Columbia (2003):

> *"1 The 'can do' attitude and 'perfect place' culture* [meaning the attitude of the organisation is that everything is perfect, whereas a high reliability organisation is characterised by a healthy preoccupation with failure].
>
> *2 Torrent of changes and organisational turmoil.*
>
> *3 Imposition of 'business' principles.*
>
> *4 Cuts in resources and manpower.*
>
> *5 Dangers of outsourcing to contractors.*
>
> *6 Dilution of risk management processes.*
>
> *7 Dysfunctional databases.*
>
> *8 'PowerPoint engineering'*
>
> *9 Uncertainties as to Out-of-Service date.*
>
> *10 'Normalisation of deviance'* [meaning the acceptance of events that are not supposed to happen. There was a fourfold increase in fuel leaks between 1983 and 2006 to around 40 per year; no trend analysis was performed so the increase in leaks was not identified. Leaks on large legacy aircraft were viewed as inevitable. There was an overoptimistic assessment of the risk/hazard posed by fuel leaks; aircraft were designed to be "leak tolerant", however it is not possible to control all ignition sources.]
>
> *11 'Success-engendered optimism'* [meaning that a risk has been avoided in the past so it is believed it is unlikely to occur in the future, as opposed to problem anticipation, learning lessons and doing the utmost to ensure it never happens again].
>
> *12 'The few, the tired'"* [lack of human resources, overstretch with increasing operational commitments]

The H-C Review also found parallels with the Zebrugge Disaster (1987), King's Cross Fire (1987), The Marchioness (1989) and BP Texas City (2005), identifying that organisational causes are fundamental to many major accidents. The Columbia Accident Investigation Board stressed the importance of identifying organisational causes rather than focussing on errors and omissions by individual employees. Management action that is indicative of a 'blame culture' (e.g. finding out which front line operator failed and sacking them) does little to prevent future accidents. It would appear from these highly studied 'big incidents' that similar occurrences may be made less likely by putting in place effective organisational barriers (e.g. proactive auditing), which can break the causal links and make it less likely that any employee fails. (See below for further discussion.)

There was a failure to learn lessons from previous incidents (from both the Nimrod and other MOD aircraft); they were treated as one off incidents rather than looking at the wider implications. There was a failure to join the dots between incidents that in themselves were not safety critical, but in combination could lead to something more serious.

The continual shifting of the out of service date of the Nimrod led to problems in planning, spares, sourcing and long-term investment. There was a policy of corrective maintenance rather than preventative. The safety case for Nimrod was described as a "tick-box" exercise which assumed it was "safe anyway".

The H-C Review identified:

- A cultural switch from airworthiness to budgetary;
- An increase in self-preservation management and regulation;
- The role of Chief Engineer was watered down, with the responsibility for airworthiness being removed from one individual and diluted down to many;
- Engineering personnel were distributed to non-specialist leadership;
- Specialists being led by Generalists which is believed to have had an adverse effect on safety.

Haddon-Cave also found problems with MOD personnel:

> "1 Undervaluing and dilution of engineers and engineering skills.
>
> 2 Engineers are not required to have professional status.
>
> 3 Decline in the ability of the MOD to act as an "intelligent customer".
>
> 4 Turf wars and inter-service rivalries for jobs and roles.
>
> 5 Short term two-year postings.

6 Constant re-naming of posts.

7 'Double-hatting' and 'gapping'.

8 Lack of trained Safety Engineers.

9 Selfishness, rewards and promotion for 'change'.

10 Shortage of manpower and skills fade. [Overstretch]"

2.2 Columbia

In February 2003 the Space Shuttle Columbia disintegrated as it re-entered Earth's Atmosphere, killing all seven astronauts on board. The Columbia Accident Investigation Board (CAIB, 2003) found many contributory factors.

Damage to the Space Shuttles, caused by debris, occurred on every flight, most of which was caused by strikes from foam insulation from the Space Shuttle external tank (65 out of 79 for which photographic evidence is available). Early in the Space Shuttle programme foam loss was considered a dangerous problem; it was designed such that no ice or debris would be shed on take-off. On its first flight Columbia needed 300 tiles replaced due to damage by debris; it was stated that if the size of the debris shower had been known it would have been difficult to clear Columbia for take-off. With each successful space flight, the foam shedding came to be regarded as inevitable and either unlikely to jeopardise the shuttle or an acceptable risk. Damage due to debris eventually was viewed as a "turnaround" issue rather than a safety risk. Acceptance of foam shedding was therefore a creeping change to the original design and operating philosophy. This was termed "normalisation of deviance" by the Sociologist Dianne Vaughan.

Damage caused by foam strikes eventually caused its loss when hot atmospheric gases were able to penetrate the wing on re-entry causing its destruction.

The report found that NASA failed to adequately perform trend analysis on foam losses; this greatly hampered the ability to make informed decisions.

There were also some further underlying creeping changes. It was found that US policy often switched between the extremes of treating the shuttle as "going out of business" to anticipating at least twenty years of further use. The result was limited and inconsistent upgrades to the shuttle and infrastructure, with investments in upgrades delayed or deferred. There was also pressure from management to meet schedule dates for space shuttle flight for political reasons.

A NASA report in 2000 highlighted concern about staff reductions, with some technical areas being "one deep". The report recommended that the workforce be increased with NASA personnel rather than contractors. The report was also concerned by the erosion of risk management by the desire to reduce costs and the complexity of the NASA/contractor relationship.

The high cost of shuttle operations was found to have forced NASA to divert funds allocated for safety upgrades to other purposes such as operations, obsolescence and infrastructure. The problems associated with the changing planned retirement of the shuttle also affected the infrastructure. The Kennedy Space Centre was described by a Congressional Committee as being in a "deplorable condition" due to its exposed salt water environment.

2.3 King's Cross

On 18 November 1987, a fire broke out in King's Cross Underground Station killing 31 people and injuring over 60 others. HSL contributed to this investigation (Fennell, 1988). There had previously been 800 small or incipient fires on the underground network; these had become to be viewed as inevitable and an occupational hazard. There was a view that fires will be dealt with when they occur and a false sense of security developed as no previous escalator fire had caused a death. Eventually, on the night in question a flashover occurred from the escalator fire into the ticket hall. Organisational failings were found by the report, for instance no one person had overall responsibility for safety and a "blind spot" occurred with regard fires to on escalators and passenger safety. In this case creeping changes, particularly resulting from an ageing infrastructure, led to increasing incidence of fire.

2.4 Texas City

The explosion at BP Texas City in 2005 killed 15 and injured nearly 200; its causes have been investigated and widely written about (Hopkins, 2009). Almost everything that went wrong to cause this incident had occurred before, either at Texas City or elsewhere, yet the lessons had not been learned. It is vitally important to learn lessons from previous failures, as Judith Hackitt, Chair of HSE commented at the Piper 25 Conference:

".....there are no new accidents. Rather there are old accidents repeated by new people."

A wide range of organisational failings were found during the investigation, only some of which will be written about in this summary. There was a culture of "casual compliance" with procedures at the time of the incident; this was in part due to procedures being outdated and not covering all possible critical events. Despite this, managers certified the procedures as being complete and up to date, and sent signals that procedures were not strict instructions but to be used as guidance. This resulted in the distillation column being overfilled, and on start-up flammable material expanded into the gas line at the top of the column and out of a vent. On at least six other occasions in the previous 10 years releases from the same unit had resulted in vapour clouds. The vapour cloud on this occasion was ignited by a vehicle that had been left running while unattended despite this being against procedures (the procedures also contained exemptions to this that were unclear), it was admitted there was no effective vehicle control policy.

The death toll was so high at Texas City is because of the presence of temporary trailers so close to the distillation column. These trailers were used to house maintenance workers that were working on a nearby unrelated processing unit. Trailers had been located in this area for 30 years during maintenance shutdowns, however nobody had ever questioned siting workers so close to hazardous equipment. The policy at the time had allowed the siting of the trailers within 350 feet of hazardous equipment on a case by case basis judged by a risk assessment; in this case the risk assessment was flawed in part due to a lack of competence from those doing the risk assessment and a confirmation bias.

Key creeping changes were therefore the reduction in the status of procedures and the long-term acceptance of temporary trailers close to hazardous equipment.

Hopkins (2009) drew parallels with the losses of the Columbia and Challenger Space Shuttles in that there was a tendency to "normalise the risk": should a process be closed down or is it reasonable to accept an increased risk for a short period when a safety system failed? A few hours more operating would make only a small difference to the risk, but it is hard to know how long the degraded state would last. The longer this lasted, the more likelihood there was of normalising the situation such that the greater risk becomes viewed as normal.

A reoccurring theme in major accidents (see for example Macondo, Esso Longford or the Moura Coal Mine) is the focus on personal safety instead of process safety; more attention is paid to high-frequency low-consequence incidents such as trips, slips and falls than is paid to low-frequency high-consequence events such as fires and explosions. Lost-time injuries (LTIs) have often been used as a measure of safety, not only is this an unsuitable measure when we are looking at low-frequency high-consequence events because of the low number of incidents that occur, but it can be carefully managed for instance by the "walking wounded" returning to work on alternative duties. Decentralisation at BP had impacted upon process safety, Texas City had a process safety specialist but he had little influence with site management and did not have a reporting line to technical authorities higher in the company. Bonus pay at BP was in part determined by safety performance, at the time of the Texas City explosion this was measured by injury statistics.

Budget priorities at Texas City combined with the focus on personal rather than process safety undermined the risk management, the only expenditure on safety was that to bring the site into line with regulatory requirements making it difficult to implement the lessons of previous accidents which would have required much greater spending on process safety. Benchmarking of costs across the industry led to BP cost cutting at Texas City; however this data did not take account of the costs involved in running that particular refinery due to local circumstances.

3 Offshore examples

The examples in this section are taken from the earlier HSE Key Programme 3 (KP3) on offshore asset integrity (HSE, 2007). Figure 1 shows a corroded temporary refuge (TR) found on an offshore installation. The temporary refuge is a structure designed to protect workers offshore for up to an hour in the event of a fire or explosion; the TR is designed to both protect against fire but also stop flammable gases from entering inside. The structure supporting the TR in the figure has corroded to such an extent that it can no longer support its own weight on top of the beam, meaning that not only will it now have a higher ingress rate but it has also had to be supported on blocks. This is a creeping change because clearly a TR would not be installed in this condition, it has gradually deteriorated to this state and nobody on the installation has reacted to the creeping change, meaning the increase in risk due to the degraded TR has become normalised. This is the "normalisation of deviance" that Haddon-Cave (2009) referred to into the report on the Nimrod loss.

Figure 2 shows a deluge nozzle that is intended to protect a pressure vessel in the event of a fire. However, during some maintenance work a scaffolding pole has been erected directly in front of the nozzle meaning it no longer protects the pressure vessel. Maintenance work, and the associated scaffolding, on ageing assets can become semi-permanent meaning this may become a long term degradation of an important safeguard. Again, this is a "normalisation of deviance" as people on the asset have ignored the increased risk.

Figures 3 and 4 show what appears at first glance to be more minor creeping changes, in that the handrails and gratings have corroded. Coatings are lost and structures corrode, and this can obviously occur to a certain extent without dramatic effect. However, in this case it appears to have just been accepted (creeping change) until it reached an extremely severe and unacceptable extent. It is difficult to tell the difference between a structurally sound grating with surface corrosion and a grating that has corroded to such an extent it will no longer hold somebody's weight. Also, if these corroded handrails and gratings are in a part of an installation that is rarely visited, somebody may enter the area in the event of an emergency not knowing if the infrastructure is safe.

Figure 1: A temporary refuge supported on blocks when its structural integrity had been diminished by corrosion.

Figure 2: A deluge nozzle protecting a pressure vessel blocked by a scaffolding pole.

Figure 3: Corroded handrails and gratings.

Figure 4: A close up view of the corroded gratings.

4 Types of creeping change

There is a broad spectrum of changes that could be classified as creeping changes and some of them are discussed in this section. However it is not an exhaustive list and other types of creeping changes can clearly occur. Typically, creeping changes occur at the interface between process safety, mechanical engineering and human factors. Problems often arise when many types of change occur simultaneously because of the difficulty in assessing their interactions.

Identifying different types of creeping change was the subject of one of the interactive sessions at workshops run by the authors for industrial delegates following KP4. The broad themes in the sub-sections below were used as a starting point for the discussions and the findings are noted here. Some of the creeping changes and issues identified crossover from one category to another, demonstrating how multiple changes can interact.

There was clear acknowledgement from the delegates of the insidious and widespread nature of creeping change and how it pervaded a wide range of critical aspects of asset integrity management (AIM) in the offshore industry. Delegates recognised that attention moves over time, and gradual deteriorations/ changes often do not get identified until too late unless there has been a clear anticipation of the need for proactive action to seek out such indications.

The "continuous change" culture of the offshore industry exacerbates this, so a strong message from the interactive sessions was that proactively identifying these issues at an early stage is essential. It was recognised that areas which lack clear performance standards are particularly vulnerable to creeping changes, which then may be ignored or not identified. Examples provided included instances where "pass" criteria were subjective or where there were no clear control or corrosion limits.

The following are based on discussions in the interactive sessions during the workshops.

4.1 Ageing/degradation/obsolescence

Creeping or gradual degradation often goes un-noticed because the rig personnel are busy dealing with short-term asset integrity problems, often there are no systematic studies/audits being performed that could identify creeping change. There may be a lack of planned maintenance in some situations; a deferral culture as opposed to preventative maintenance.

Temporary repairs/patches or workarounds have a lifetime associated with them, and are meant to be short term fixes; however these can sometimes become long term in nature. It is a common failure to not regularly review if equipment is fit for purpose and understand the condition of the asset.

There can be failures to update technology, companies keep repairing equipment until they can no longer get spares or get someone who can repair the equipment. Some companies are starting to consider these issues as part of obsolescence studies but not necessarily for all systems and equipment. Obsolescence issues, especially when there is a gradual deterioration of vendor support or spares availability, often do not become apparent until there is a breakdown. Control systems are particularly vulnerable as electronic circuit boards cannot be replaced. The loop diagrams often do not reflect the control system in place; this may be due to the drawing not being updated to reflect any changes that have been made. Marine systems are also vulnerable because of the difficulty to modify or get spares.

Changes by manufacturers are not always effectively communicated to users until they require spare parts or replacement equipment. Issues occur when like-for-like replacements or spares cannot be obtained. In many situations this can be mitigated by service level agreements, but the organisation must proactively address this. Often a supplier is no longer in business, therefore, planning is required to anticipate future issues. New technology is often ignored; the company should consider replacing obsolete equipment, where possible, with newer technology. This would not only help to resolve the obsolescence issues but also provide a degree of future proofing and enhanced performance.

Positive feedback about the industry's ability to respond to obsolescence included a number of examples where initial lack of replacement parts etc. was resolved by re-manufacture of identical parts.

4.2 Process changes (including reservoir changes offshore)

Process changes can be either chemical or physical, and could result in increased degradation rates. Chemical changes include, for example increases in hydrogen sulphide, whereas physical changes most often reported were changes in the temperature and pressure. The hazard associated with some physical changes, such as reducing pressure, may not always be obvious, but these changes can have unintended effects such as deposition of material or stagnant areas due to the reduced flow. The effect of this could be increased if combined with other changes such as material degradation due to age.

Changes in produced fluids over time need to be monitored and relevant action taken to change process parameters so alarms and safety systems still work as required. However this is not always the case. Process systems are sometimes bypassed due to difficulty to manage/operate because of changes in operating conditions and/or lack of suitably skilled personnel to maintain and run them.

The significance of ancillary process systems, or parts of the process which were traditionally considered as "low priority", could be easily overlooked, and only realised when their deterioration assumed critical importance. Examples of this phenomenon included the failure of cooling water filtration systems causing significant production outages, and pipeline deadleg corrosion. Delegates considered that a good mechanism for ensuring that such issues were identified was the use of appropriate HAZID techniques focusing on the consequence of creeping change across all the process plant.

4.3 Equipment/infrastructure changes (including structural and civil engineering)

Creeping changes are a significant issue with coating damage on offshore structures, probably because little effort or thought went into defining appropriate acceptance limits. Lack of corrosion limits in guidance is a major problem offshore, partly because there is a culture of accepting this as something that occurs, so it is a low priority issue and does not get dealt with.

There is similar poor prioritisation offshore regarding the condition of some items of critical equipment if it is not something that is being dealt with. Areas of the rig will often have critical equipment but are ignored until something goes wrong.

Crane man-riding capability is an issue, but this was not considered a good thing at one time, so when cranes required repair to maintain their rating for man-riding they were simply de-rated to avoid having to repair it, meaning man-riding was no longer allowed. However, this consequently caused problems when there is a need to take personnel off the rig onto, for example, a sleeper vessel or other vessel.

4.4 Management/ownership changes

Changes of operator or installation ownership are events which increase the probability of creeping change going unnoticed because of the potential for losing infrastructure information and intelligence due to changes in personnel or systems. Delegates highlighted that the churn in operators/owners was leading to a significant vulnerability on the UK Continental Shelf (UKCS). Conversely, though, there was an acknowledgement that a "fresh pair of eyes" was often a way in which creeping deterioration could be identified.

The continual change that is experienced offshore was flagged as a big problem, as was contractual changes because the new contractor will inevitably do things differently, as well as the loss of knowledge that the old contractor had accumulated. There can be problems with exit strategies, companies fail to develop a rig 'hand over' strategy when they sell, and fail to supply information to the new operator.

"Silo" organisations are problematic, leading to little or no sharing of knowledge from one part of the organisation to another. Alignment, communication and understanding of shared objectives and goals between parts of the organisation do not always happen. There can be a tendency not to check other rigs/operators for good practice, and also may not consult engineers/technicians on the rig. This has caused issues between management and technical authorities (TAs) who have different focuses, management objectives tend to be short term issues such as profitability rather that longer term issues such as ALE that the TA would manage.

4.5 Workforce changes/loss of skills

A host of workforce factors associated with creeping changes were identified, which are just as significant as more infrastructure-linked factors. For instance, issues of delayering the workforce, increased use of contractors and the changing demographics with more inexperienced workers is leading to a loss of knowledge in the older systems as workers leave the industry.

Personnel turnover leads to a loss of experience and asset history, and this has been recognised as a major issue both offshore and onshore. Reorganisation / delayering can lead to a reduction in ALE issues being addressed as knowledge of the problems and focus upon them can be lost. The right people are not always in the right place to keep on top of the work that needs to be done, leading to jobs being left undone and workarounds and other temporary measures being left in place. There can be an over reliance on Safe Systems of Work (SSOWs) instead of the competence of the workforce (which would be inherently safer).

4.6 ORAs/MOCs

Operational risk assessments (ORAs) are put in place while safety barriers are down which is often related to creeping change. ORAs are sometimes used in lieu of repair because of obsolescence problems. There can be an impact on production dependant on the barrier(s) that are down, and if an SCE barrier is down on any production critical system or equipment then production is stopped until a fix is implemented.

Depending on the scale of the incident or other issue, multiple ORAs may be in place to cover multiple barriers being down, associated with significant creeping change. Interlinked ORAs / long term isolations (LTIs) may be in place due to a failure arising from an incident caused by creeping change. The cumulative effect of these can be hard to assess.

ORAs used as a means of managing a backlog is a problem, where the cumulative effect can be that a number of barriers are potentially not fit for purpose and temporary repairs become effectively semi-permanent. Lack of action/close out of ORAs can occur where they are in place for a significant time due to issues such as lack of maintenance resource, spare parts or relevant skilled personnel, or a lack of perceived urgency now that a fix is in place, indicating a lack of rigorous follow up.

Multiple management of change (MOC) processes have the potential to cause creeping changes by interacting with each other, or interacting with other creeping changes, if the effects of the change are not carefully examined during the MOC process.

4.7 Culture

Cultural changes are unique in that not only are they a type of creeping change, they are also a possible defence against them and are discussed further in section 8.

There were strong views during the workshops that creeping changes were more of an issue in organisations which had a “deferral culture”. Where this happens, short term/quick fix AIM decisions ignore the cumulative effects of, for instance, the extensive use of temporary repairs or ORAs. A strong Technical Authority (TA), able to take a long-term view to counter-balance more production orientated short-termism, was considered vitally important here.

One particular issue that was raised was deluge systems blocking over time, and because no investigation is performed personnel are ignorant of the root cause of the blockage. The system is repaired and quickly becomes blocked again. This is a recurring theme, and does not apply solely to deluge systems. It is vitally important to learn lessons of previous failures rather than just fixing the problems to prevent them from recurring.

5 Atypical events

Many creeping changes can be readily identified as being potential safety issues (or otherwise) when given sufficient attention. Atypical events, however, are those for which there is insufficient knowledge to understand the safety issues that they pose. The Buncefield incident was an atypical event in the sense that before it occurred common understanding within the process safety community was that a vapour cloud explosion (VCE) could not occur in the absence of semi-confinement or congestion. Atypical events could therefore be associated with a sub-set of creeping changes for which the change is allowed and believed to be non-hazardous because of lack of knowledge.

Identification of atypical events requires focussed internet/ literature searches alongside hazard identification. The DyPASI hazard identification technique (Paltrinieri, 2013, 2014) was specifically developed for that purpose.

6 How to address creeping changes

6.1 Periodic reviews/audits

It was commented in the KP4 report (HSE, 2014) that “a new pair of eyes” is often helpful in identifying creeping changes. Periodic reviews/audits by personnel not associated with the installation are needed to identify any potential creeping changes. The person(s) conducting these audits need to be suitably independent and unfamiliar with the installation and its practices so that they are not subject to the “normalisation of deviance” that its workers may be.

6.2 Creeping change HAZID

A HAZID methodology is in development at HSL specific to identify and eliminate creeping changes, since the need to recognise and address creeping changes was a clear need highlighted by KP4. This involves the use of keywords to use in a HAZID workshop to brainstorm possible creeping changes that have/are taking place. These possible creeping changes can then be subject to a risk evaluation process to identify the most important/high risk areas which are then subject to monitoring or remediation.

6.3 Monitoring of changes - KPIs and data trending

As an asset ages, it is important to monitor changes that are occurring and predict their effect on the asset in the future. A possible methodology is shown in figure 5. This is important for both safety and production, to avoid deterioration of critical safeguards and to prevent unplanned shutdowns. Appropriate leading KPIs and data trending will be required to aid this (Chambers, 2015). Creeping changes are one type of change and other ageing issues that need to feed into this process.

The key is to identify those changes, including creeping changes that are important. This could be done on the basis of an assessment of likelihood and consequence. Management would then include measurement, both for the purpose of determining key performance indicators (KPIs) and to trend the measurements to predict the remaining asset life. These are important inputs to decisions about repair or replacement programmes for equipment, and also to maintain management awareness and control of cultural issues (see below).

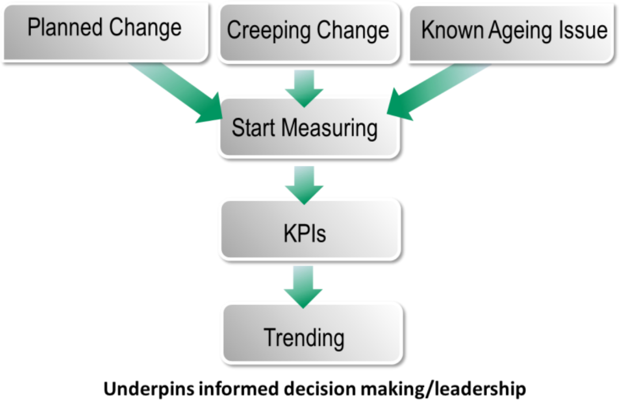

Figure 5: A possible methodology to deal with changes that occur as an asset ages and plan for life extension.

6.4 Safety culture

The principles of high reliability organisations and mindful leadership may be applied to identify creeping change, for example procedural drift, or prevent them from occurring (see section 7 for more details).

7 Organisational Culture

7.1 Definition/explanation

Organisational culture is 'the way we do things around here' (Drennan, 1992). It is the shared values, beliefs, attitudes, habits. assumptions and expectations of employees. It is influenced by management commitment and a willingness on the part of the workforce.

Safety culture is a subset of organisational culture (HSE Common topic 4 - safety culture, HSE, 2005) and it relies on a commitment, particularly from leaders, to actively manage major hazards (process safety leadership) including:

- a focus on major accident hazards, as well as personal injury
- awareness of the possible bias of production over safety
- awareness of all available reliable measures of health and safety (reactive and proactive) to manage major hazards
- awareness of normalisation of deviance/creeping change.

Walking on by, complacency and 'turning a blind eye' to unsafe practices and behaviours by leaders is not conducive to a safe culture.

7.2 Procedural drift

Procedural drift is an example of cultural creeping change, which with mindful leadership (see below) can be managed and reversed with timely, informed and targeted management action. A typical scenario of procedural drift is where official safe procedures are put in place to ensure the workforce are using recognized safe practices and exhibiting safe behaviours, but over time, the procedures change (creeping change) and informal procedures take the place of the original procedures. Many organisations (e.g. HROs) develop procedures by engaging with the work force, ensuring the procedures are workable (user friendly), and can be easily accessed. Sometimes over time the procedures can appear to the workforce as outdated, irrelevant, inaccessible and as a result they start to be ignored. Complacency may begin to take hold; new starters pick up the bad habits of using the new informal procedures that have taken the place of the official procedures, employees think they are acceptable forms of practice, and if unchecked, and not managed, routine non-compliance with the original official procedures becomes common place, the norm (i.e. routine violation).

To prevent this some organisations (e.g. HROs) ensure procedures are living documents, updated regularly (with participation of the workforce), that new starters receive training that ensures they are aware of the correct process and procedures, making clear the need to follow the procedures (i.e. that their role is safety critical and failure to follow the correct procedures could result in a major incident). In this sense employees are made increasingly aware of the likelihood of a major incident and the role they have in prevention. This awareness, vigilance and chronic unease is a feature of HROs and mindful leadership.

7.3 Mindful Leadership

Mindful leaders have a preoccupation with failure *(the possibility of failure keeps them awake at night).* To manage health and safety risks effectively leaders rely on robust, comprehensive and valid health and safety data (reactive and proactive), that is rigorously analysed and then presented in a way that is easily understood, whatever the background of the member of senior management.

The sense of chronic unease that mindful leaders feel makes them suspicious when all they hear is good news *(bad news tends not to travel easily to the ears of senior management*). The lack of bad news is seen by mindful leaders as a warning sign in itself, to be followed up by inspection and auditing. Ideally mindful leaders collect health and safety data directly by personally carrying out their own audits and inspections, talking to front line operators directly, and observing practices and behaviours first hand.

Mindful leadership is a potential solution to enhance process safety leadership in a major hazard environment as discussed by Mellor (2015) and Weick (2007). Indeed, mindfulness meditation practices could help all levels of the workforce to increase awareness which would be expected to assist in the recognition of creeping changes.

7.4 Inspection and audits

Senior management health and safety inspection and audit activity sends the message to the workforce that health and safety is important to the organisation. Such activity is often informed by data collected by third party auditors and inspectors (e.g. contractors), while retaining the organisation's intelligent customer capability. This approach has the advantage that a 'fresh pair of eyes' will often notice things that have been taken for granted by those within the organisation (e.g. the routine violation of procedures).

In the future it is possible that audits will be developed that specifically pick up the signs of creeping change (the authors are currently looking into developing such an approach, i.e. a creeping change HAZID). There are also tools such as the Safety Climate Tool (SCT) (Sugden, 2013) that can measure an organisation's attitude to risk (e.g. peer group attitude). If workers are identifying risk and walking by, then by the very nature of this behaviour they are 'turning a blind eye' and have accepted these unsafe practices or behaviours. There may be pressures of productivity over safety (also measured by the SCT) that lead to such acceptance and an unsafe culture.

8 Conclusions

Creeping change is an important issue in almost all industrial activities and its identification and elimination is key to ensuring safety and to maintain production efficiency. It was highlighted by the HSE KP4 inspection programme as an important issue to address when managing ageing assets. Creeping changes can have potentially catastrophic effects on both major hazard safety and production.

Creeping change covers a range of issues in equipment integrity, reservoir and production conditions, and human factors and organisational culture. Creeping changes are those changes that occur gradually and slip under the radar of processes to identify and manage hazards.

A HAZID method to identify creeping changes is needed, and is in the early stages of development by the authors.

A toolkit to address creeping changes would include:

- identification (HAZID)
- periodic reviews/ audits by a 'fresh pair of eyes'
- monitoring changes and taking appropriate and timely decisions to prevent failures
- awareness and prevention of procedural drift
- moving towards a culture of mindfulness including mindful leadership
- embedding HRO principles within the organisational culture

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10 References

Chambers, C. (2015), Data trending to support Aging and Life Extension (ALE) in the United Kingdom Continental Shelf (UKCS) Oil and Gas industry, IChemE Hazards 25 Symposium, Edinburgh

The Columbia Accident Investigation Board (CAIB) (2003), Report Volume 1, Washington, D.C.: National Aeronautics and Space Administration and the Government Printing Office

Drennan, (1992), Transforming Company Culture, London: McGaw Hill

Fennell, D. (1998), Investigation into the King's Cross Underground Fire, London: The Stationary Office

Hadden-Cave, C. (2009), An Independent Review into the Broader Issues Surrounding the Loss of the RAF Nimrod MR2

Aircraft XV230 in Afghanistan in 2006, London: The Stationary Office

Hopkins, A. (2009), Failure to Learn: The BP Texas City Refinery Disaster

HSE (2005), Inspectors Toolkit: Human Factors in the Management of Major Accident Hazards http://www.hse.gov.uk/humanfactors/topics/toolkit.pdf (accessed 09/01/2015)

HSE (2007), Key Programme 3 (KP4): Asset Integrity Programme http://www.hse.gov.uk/offshore/kp3.pdf (accessed 09/01/2015)

HSE (2014), Key Programme 4 (KP4): Ageing and Life Extension Programme http://www.hse.gov.uk/offshore/ageing/kp4-report.pdf (accessed 09/01/2015)

Lekka, C. (2011), High Reliability Organisations: A Review of the Literature, HSE RR899

Mellor, N., Wilday, J., Lunt, J., Holroyd, J. (2015), High reliability organising principles and mindful leadership, IChemE Hazards 25 Symposium, Edinburgh

Paltrinieri, N., Tugnoli, A., Buston, J., Wardman, M., Cozzani, V. (2013). Dynamic Procedure for Atypical Scenarios Identification (DyPASI): a new systematic HAZID tool. J. Loss Prev. Process Ind. 26 (4), 683–695.

Paltrinieri, N., Wilday, J., Wardman, M., Cozzani, V. (2014), Surface installations intended for Carbon Capture and Sequestration: Atypical accident scenarios and their identification, Process Safety and Environmental Protection, 92 (2014), 93-107

Sugden, C., Roberts, K., Preston, M. (2013), Measuring the Safety Climate in Organisations: Reduce Injuries and Costs Through Cultural Change, Available from http://www.hsl.gov.uk/products/safety-climate-tool/free-white-papers- (accessed 09/01/2015)

Weick, K.E., Sutcliffe, K.M. (2007), Managing the Unexpected: Resilient Performance in an Age of Uncertainty, Second Edition, San Francisco: Jossey-Bass