PASS IT ON! REVISITING SHIFT HANDOVER AFTER BUNCEFIELD

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Since it was first recognised as a key issue after the Piper Alpha disaster, failures in shift communication, including shift handover, continue to be a significant contributor to industrial major accidents worldwide and are now increasingly recognised as critical in other domains such as patient safety. This paper reviews the current literature and uses the Buncefield oil storage depot explosion and fires as an exemplar incident. It then reviews what is known about handover and whether there is a knowledge or application gap for the on and offshore major hazard sector. Finally, it compares the onshore major hazard industry experience to that for offshore oil and gas. The review concludes that, despite the increasing interest in this topic, there has been little new original research since Lardner's seminal work in 1992. A number of papers have attempted to tailor what is already known about handover and apply it to new domains such as patient safety. In other key industry sectors, the focus is significantly narrower and more specialised e.g. for air traffic control (ATC), aircraft maintenance, and spacecraft ground control. The nuclear sector, while it has done much to progress this issue within the industry, has published little in the public domain. Going forward, the review identifies the main gap in the application of existing knowledge about good practice in handover, and not in the underlying research. There is also an over-focus on shift-to-shift handover specifically and not on wider – but equally critical – within-shift and shift/days or shift/management communication issues. The lessons from Buncefield, while identified at a general level, lack the impact that a fuller understanding of the background story leading up to the incident could provide. With respect to offshore, some unique features of the offshore working environment are identified as making shift communication and handover even more difficult and important to manage. For example, it is argued that offshore working is in effect a complete shift operation because of the physical separation from onshore and this exacerbates communication difficulties with the shore or 'beach'. Finally, recommendations are made for the way forward for both the on and offshore sectors.'

INTRODUCTION AND BACKGROUND

Failures in shift communication, including shift handover, continue to be a significant contributor to industrial major accidents worldwide and are now increasingly recognised as critical in other domains such as patient safety. The importance of shift changeover was particularly highlighted in the UK – and subsequently worldwide, especially within the oil and gas industries – after the 1988 Piper Alpha disaster and Inquiry (*Cullen Report*) (*HSE 1999*), though it was well-established as a key safety issue before this (*HSE 1996*). It has been highlighted again in accidents many times since, most recently after Buncefield (Buncefield Oil Storage Depot Explosion and Fire, 11 December 2005 – (*Buncefield 2005*)) and in the US CSB investigation report of the BP Texas City refinery accident (*CSB 2007*).

Safety critical communication is involved in practice in a much broader range of activities e.g. (adapted from (*HSE IT*)):

- Emergencies, where communication is paramount
- In processes or activities involving remote communication, for example between control room and field staff such as process start-up and shutdown
- Permit-to-work both within and across shifts
- Communications with contractors and other third parties
- Use of radio, phone, email, verbal, written and other communication methods
- Plant & equipment identification and labelling; for example, in communicating clearly for isolations and related maintenance activities
- Communication of changes to rules, procedures and other key safety management system elements
- Communicating key issues, control measures and related key information from safety case analysis and allied hazard/risk analysis. This includes management communications especially in the major hazard sector.

SHIFT COMMUNICATION

The focus in this paper is on shift communication in general and shift handover in particular. Shift handover is the best known type of safety critical communication and in fact much of the literature focuses on this area. Effective shift communication, including shift changeover (see definition below), requires effective, structured and formal communication arrangements in direct proportion to the risks and hazards of concern.

Communication within an organisation where some employees work shifts will always require more effort and focus to be successful, and is especially important where the nature of the operations is safety critical with respect to major hazards. For offshore, this is compounded by the nature of the work where there is a physical and geographical divide between central/shore functions and the offshore assets.

The key element within which shift handover is important is that of shift communication (HSE 1999; Lardner 1992) and this entails a wider area of concern: *'Effective communication is important in all organisations when a task and its associated responsibilities are handed over to another person or work team. Critical times when good communication must be assured include: at shift changeover, between shift and day workers, between different functions of an organisation within a shift (e.g. operations and maintenance) and during process upsets and emergencies.* (*HSE SH*) For offshore, this would also include communication between key functions offshore and on the beach.

DEFINITION OF SHIFT CHANGEOVER

To help set the scene for the review, here is brief reminder of the definition and key factors for effective handover at an individual level. Shift handover is one of three key elements in a shift changeover, typically including *"1) a period of preparation by outgoing personnel, 2) shift handover, where outgoing and incoming personnel communicate to exchange task-relevant information and 3) cross-checking of information by incoming personnel as they assume responsibility for the task. The goal of shift handover is the accurate, reliable communication of task-relevant information across shift changes, thereby ensuring continuity of safe and effective working." (HSE 1996).*

'To maximise effectiveness, individual handovers should be conducted face to face, with relevant information present (eg logs, computer displays). Incoming and outgoing personnel should both participate in a two-way dialogue, which allows for questioning, explanation and clarification. It is important that individuals are aware of company standards for handover, what is expected of them and which handovers are high risk or potentially problematic.' (HSE SH).

Further to this, high risk handovers are identified as *(adapted from HSE SH)*:

- After a lengthy absence from work e.g. at crew change or after long rest periods
- Between experienced and inexperienced staff
- During a plant or process upset
- When maintenance activity spans shift handover(s)
- When safety systems are over-ridden or otherwise not available.

KEY FACTORS FOR SUCCESSFUL HANDOVER

A number of key points were identified from a review of the research and guidance carried out by the first author as part of the Buncefield investigation (the main sources are available on the HSE web pages on Safety Critical Communication and Shift Handover (*HSE SCC*)). This confirmed that relevant HSE guidance had been readily available for some time before the accident, starting in 1989 with the first edition of HSGE's core human factors' guidance (*HSE 1999*), and had been regularly used by the onshore major hazard industries to develop and improve shift changeover arrangements.

The key organisational issue supporting successful handover is that the importance and high priority of reliable communication is formally recognised by the organisation and its management, and reflected proportionately in the arrangements made for this in the safety management system and the relevant risk control systems. Management should also specify at least a minimum period for handovers. Typically a handover on a 12-hour shift may last up to 30 minutes, though shorter periods may be sufficient depending on the complexity of the process or activity and current status, provided the handover is well-structured and thought-out. If this requires extra time then that should be paid or otherwise rewarded. Other ways of stressing the importance of handover include making arrangements to ensure a reasonably uninterrupted period is available for changeover i.e. time beforehand to prepare and time afterwards to consolidate/check, and planning to avoid – or postpone – key tasks during changeover, and minimising interruptions. For example control rooms may be secured against interruptions for that period, and phone calls held or kept short.

In a review of one offshore company's handover arrangements the following issues were identified as key for good practice (*Lardner 1999)*:

- The need for good design of handover logs and other records or job aids
- Use of suitably designed checklists or other prompts for handovers
- Redundancy and diversity in communication media; two-way communication and feedback.
- Specifying the time normally expected for handovers
- Analysis of information and user needs in different operating modes e.g. normal, abnormal, start-up/shutdown, maintenance (*and based on hazard/risk*)
- Use of e.g. a reading file for crew changeovers or after long rest periods so new crew can catch up fully with what has occurred in the intervening period
- Specifying the importance of group handovers as well as individual ones.

Other specific measures for assuring successful changeover include the provision of the necessary resources (including time), and provision of guidance and training for the staff involved. A number of more specific examples of ways of assuring that reliable transfer are also given in the guidance. In addition to the repetition of key information in different media e.g. written and verbal, personnel involved should actively confirm and clarify the key information when communicating it. It is also important to minimise unnecessary information so that the system does not become devalued. Finally, in identifying key operator support/aids for handover, use can increasingly be made of electronic information – including e-logs – and display screens e.g. for control room operators to cycle through both as part of handing over the plant or process and as an error-trapping

exercise to make sure that incorrect assumptions are not made by either operator.

The identification of high-risk handovers is also very important (see section above on shift changeover for examples). Some of these may be specific to the kind of industry, or process concerned.

In the major hazard sector, the key information to be identified for handover should include that necessary for the control and prevention of major accidents, and not just for occupational health and safety issues as in the non-major hazard industries.

The review also identified that shift length affects handover significantly. A 12-hour system offers continuity improvements with a smaller number of handovers and an increased number of these where the same staff are involved i.e. the outgoing person gives the handover at one end of a shift and receives it at the other. It can also improve communications with maintenance and production staff because more maintenance work can be completed within-shift. Disadvantages include: reduced chances to meet and communicate directly with day staff e.g. if handover is at 07.00/19.00 then day staff will not usually be present; more reliance on logs and other written communication; longer periods off duty between shift cycles so that more effort and time is necessary to bring returning staff up-to-speed on their return and for them to refamiliarise themselves with the on-going operations and maintenance picture; and there are some possible fatigue effects on alertness and performance noted resulting from the extended working periods (*HSE 2006b*).

However, although 12-hour systems may reduce the number of handovers and increase the number of same-person handovers, this can also increase the likelihood of some error types e.g. mistakes. So if for example an outgoing person briefs the incoming one incorrectly or inadequately and then returns to take over on the next shift, then this mistaken awareness or picture may persist unchallenged (this applies equally if the outgoing person leaves with an incorrect or inadequate awareness of what is going on).

METHOD

The review for this paper was carried out by a web search (using 'shift, shift handover, shift communication hand-off, handback, changeover etc.) and review of publicly available research and guidance where assessed as relevant. The main UK source for guidance is on the HSE website which the first author instigated in 2006 following a similar search and review (see section above). This followed his involvement in the Buncefield investigation where shift communication and handover were key issues.

RESULTS

RESEARCH AND GUIDANCE

The available research is very limited on shift handover. Search terms generally produced quite similar results e.g. 'shift communication' produced limited results, mainly for non-related business consultancies or companies marketing shift log software packages; 'shift' and 'shift handover' were more fruitful but still did not produce substantial results. The main primary research is by Ronny Lardner (*Lardner 1992*) even though this is now quite old and is unpublished. It was however developed into a useful paper on an application to a UK refinery, and a literature review (*HSE 1996*) for the HSE, and these are usually cited instead.

The primary source for guidance and research on shift communications and handover is through the HSE web pages on Safety Critical Communication and Shift Handover (*HSE SCC*). The first author assembled these in early 2006. In addition to the above papers, there is also an audit method developed for HSE (*HSE Audit*) for offshore application, and an extract from an 'Inspectors Toolkit' (*HSE IT*). The toolkit includes the list provided in the introduction above (as examples of safety critical communication), of key 'inspectable' situations. The core HSE human factors' guidance (*HSE 1999*) has a short section on shift communications. The HSE information has been used regularly to train on- and offshore inspectors on this issue by the author and his then team between 2001–2010. The first author developed an in-house CPD course for HSE human factors specialists on safety critical communications with the HSE's Health and Safety Laboratories (HSL).

MAIN RESEARCH AND GUIDANCE FOCUS

The main guidance and research is directed towards on- and offshore major hazard industries in the UK but is based on a worldwide review (*Lardner 1992*). The oil and gas sector is not therefore discussed specifically further below because the results are included in the section above 'Key factors for successful handover'. Piper Alpha should of course be mentioned but the disaster is very thoroughly addressed elsewhere and the key lessons for handover are incorporated in the HSE sources. As this was such a seminal incident for the offshore sector, it is not so surprising to find that a lot of the early relevant research and guidance was triggered by it.

Transfer and application of research and guidance

In the first author's experience (from inspecting and assessing this issue over the last ten years) there is not a good or consistent transfer on human factor issues such as shift handover between the on- and offshore domains even in companies operating in both up- and downstream areas. Onshore practice does not generally appear to differ markedly but the circumstances are different with offshore which has a number of unique aspects (see section below). Other sectors (discussed below) reference the primary research *(Lardner 1992)* and HSE and there is better – if still limited – evidence of transfer here.

OFFSHORE AND ONSHORE DIFFERENCES

Onshore practice in the major hazard (COMAH) industries reflects a wider range of processes and activities, so that for

example process complexity (or lack of it) can be a factor differentiating practice from offshore. Onshore gas and oil terminals are probably the closest comparators but there are some unique aspects to the offshore situation such as tour arrangements, physical and environmental constraints, and crew changes.

There are several specific and unique aspects for the offshore sector. These include the use of 14–21 day tours offshore; a 12-hour shift pattern involving the same staff; very tight physical and environmental constraints; and a complete asset/shore divide. From the broader shift/day function perspective, essentially all work on installations is 'shift' and most functions are shore-based. On-offshore communications are very vulnerable to disruption and misunderstanding and require more work than onshore and other sectors. This places an even greater reliance on establishing and maintaining good communication, and not just for handovers. Some companies have been working on improved asset-shore video/sound links and trying out e.g. head-mounted cameras to aid maintenance/problem diagnosis.

The 12-hour shift pattern operated on most installations confers some advantages and disadvantages. For example handovers will involve the same people so that there is an improved chance of establishing and maintaining a shared picture of what is happening; this shift pattern also reduces the number of handovers than eg 8- or 10-hr patterns require. However this can also lead to complacency and incorrect assumptions – or shared errors – about what is known.

For crew change, the unique issue for offshore is that most crew will have had 2–3 weeks off between tours (the industry is increasingly moving towards a 3-week break between tours). This places significant additional emphasis on a good quality handover, given the sizeable decay in awareness that will have taken place over the rest period. The outgoing person will also be likely to be at their most fatigued at that stage of their tour, and transport arrangements or changes, and communication difficulties can make it difficult to secure consistent handovers. Anecdotal evidence suggests that there is sometimes too much reliance on supplementing formal changeover arrangements by quick face-to-face conversations in the heliport lounge as crews change over. The authors' own experience – and that of colleagues – is that changeover arrangements can still vary significantly between offshore companies and that higher risk handovers are not consistently identified.

OTHER SECTORS

Patient safety

There is a growing literature in the Patient Safety area though this is largely based on Lardner's work and developed for hospital and related applications. For example, a short paper was found on the American Association for Clinical Chemistry's website by the US Patient Safety Focus (*Grimm 2011*). This is referenced as a typical example of the available documents. It includes the basic guidelines from Lardner's original research via two papers from NASA (*Parkes & Mishkin 2005 – discussed below*) and from the patient safety literature (*Patterson 2004*), which in turn (see above) are based on Lardner's work. There is work available in the UK through the National Patient Safety Agency (NPSA) and in the medical literature. For example the NPSA publish guidance with the BMA on safe handover for clinicians and managers (*NPSA SH*). This documents good practice, key principles and examples for the NHS. It reflects the very complex nature of handover in a hospital setting including multiple parties, increasing patient numbers, and the involvement of more than one consultant and doctor. The good practice does not offer anything new except for a useful discussion of some of the issues around IT-based handover arrangements.

The (*Patterson 2004*) paper is particularly relevant. It is based on direct observation of handovers: in space shuttle operations, two nuclear power plants, ambulance and rail despatching. It identifies 21 key strategies for handover based on literature review, observation and interview. The paper makes recommendations for the transfer of key learnings to the healthcare setting but acknowledges this is significantly different to the domains studied. The strategies are quite detailed but do not differ significantly from the other literature discussed so they are not included here.

NUCLEAR

There is little available publicly within the nuclear industry on handover and what is available has been reviewed elsewhere (see below; and e.g. (*HSE 1996*)). Both authors have reviewed practice at UK nuclear facilities (*source: unpublished internal reports*) and have found that they differ little from that in the other onshore major hazard industries. It was though particularly well-structured and supported, well documented, and developed through nuclear benchmarking processes. Again the original research by Lardner was cited as a key source in the improvement process.

Handover arrangements at the plant involved both one-to-one defined handovers and a more general shift handover in the control room after this with all key personal from both shifts. This was largely directed by the oncoming shift manager and was brief (15 minutes) and to the point – a 'stand up' meeting around the control desks. It covered expected events, key on-going work, process issues and other key information. In effect it focused on wider shift communication issues rather than individual handover ones. Although there were good features present the arrangements still did not identify higher risk handovers for example and so did not fully approach good practice.

AVIATION

The aviation sector has more literature on this topic but this is mainly focused around air traffic control (ATC) handover and handover in aircraft maintenance. For ATC handover, relevant material was limited. One example research paper (*HFIDTC 2005*) from the UK is very method-driven – using Event Analysis of Systematic Teamwork (EAST)

method and aimed at developing a model for C4I (Computer and Intelligence Constructs) – and so not of immediate practical help. ATC handovers are also frequent within shifts (every 1.5 hrs) as well as at the end of shift. The paper does however include an element which identifies 16 key items of knowledge required for ATCs to maintain situational awareness (and therefore key issues for handover as well). This illustrates that any handover arrangements will require a level of analysis to determine what information is salient and under what operational circumstances.

The paper also identifies an existing ATC mnemonic – 'PRAWNS' – used in handover, where **P** – barometric **P**ressure; **R** – **R**unway currently in use; **A** – information on **A**rea sectors; **W** – **W**eather conditions; **N** – **N**on-standard priority information; **S** – use flight data **S**trips. The mnemonic is again based on analysis to identify key information required for handover. This approach is a very useful way of helping individuals to recall quickly and reliably what they need to record and communicate at handover.

For aircraft maintenance, an example is an extract from a defence publication for cross-services military aircraft arrangements for handover (*JSP 2008*). This has a relatively brief section on handover and is more focused towards handing over tasks i.e. part-completed maintenance work on aircraft. There are similar resources for the civil sector e.g. (*CAA 2002*). This states: *'Whilst history is littered with past experiences of poor shift handover contributing to accidents and incidents there is little regulatory or guidance material regarding what constitutes a good handover process relevant to aircraft maintenance. This chapter attempts to provide guidelines on such a process and is drawn from work performed by the UK Health and Safety Executive (HSE), US Department of Energy (DOE) and the Federal Aviation Administration (FAA).'*

An extract from Ref. 12 is reproduced in Annex 3 to show the approach taken. This includes a useful summary of what a handover is:

'Effective shift handover depends on three basic elements:

(a) *The outgoing person's ability to understand and communicate the important elements of the job or task being passed over to the incoming person.*
(b) *The incoming person's ability to understand and assimilate the information being provided by the outgoing person.*
(c) *A formalised process for exchanging information between outgoing and incoming people and a place for such exchanges to take place.'*

This simple definition emphasises that people need to understand the 'why' of handover ie why it is important, and what is important; it also stresses the communication skills and channels that are needed for both parties, and the need to formalise the process both to reduce the potential for error and to underline the importance of the process. The extract also lists the same key issues identified in the original Lardner research (and the guidance references this). Ownership and formality (of the process of handover) are emphasised and the importance of using more than one communication medium, of feedback, establishing a shared mental picture of the situation, and user involvement in handover log design. User information needs go beyond just task-specific information e.g. manning levels are also key. It also emphasises that handover – and preparation for handover – starts as soon as personnel begin their shift, and the importance of 'walking through' on-going tasks as part of handover.

There is also guidance and a number of training packages on human factors, including handover, for aircraft engineers and technicians, reflecting the relative maturity of this sector on human factors. A relevant paper from Australia is by Alan Hobbs (*Hobbs 2003*) who co-wrote a book in the same year on human error in aviation with James Reason (*Reason & Hobbs 2003*). The section on handover is brief but he does say: '*Studies in a range of industries also show that information transfer between shifts is most effective when it captures problems, possible solutions and intentions, and does not just describe what has been accomplished.'* (p22) He also notes that face-to-face handover is less common in aviation than in other comparable sectors.

There are sections on handover in other guidance and handbooks though again these are primarily task-focused and relate to complex incomplete tasks typical of aircraft maintenance. Such tasks offshore would typically be covered by PTW/Control of Work systems where they spanned shifts.

There are also papers and guidance from the related space sector, for example (*Parke & Mishkin 2005*) on best practice in shift communication based on the Mars Exploration Rover mission. This includes a checklist for handovers based on the identified best practice (see Annex 1). The introduction is worth quoting because it summarises the full research base:

> *'The Europeans have long been at work in this field, and Lardner provides an excellent review of the shift handover literature in European offshore oil, nuclear industry, and nursing. The guidelines and recommendations in the present paper are based both on this literature and the literature from various American domains such as nuclear power, air traffic control, offshore oil, spacecraft mission control, and aviation maintenance. A few of the most important best practices are discussed below. The rest are summarized in the checklist for effective handovers which follows.'*

This confirms the key domains of interest discussed in this review (though Patient Safety has been added here). While the handover needs for an extended space mission with a remotely-operated vehicle are different in some respects from other domains, the checklist also confirms that the key issues remain much the same. For example: culture and management commitment; good user input; redundancy

in communication methods; a structured written approach; allocation of time, resource and a distraction-free environment; adequate training, audit and monitoring.

BUNCEFIELD

In analysing the available evidence during the Buncefield investigation (*Buncefield 2005*), the first author's conclusions were the following.

Effective arrangements for shift changeover, including handover, were not in place. Given the 24-hour, 365-days a year pipeline and tank management operations being conducted at the terminal, involving three incoming major pipelines, very large capacity tanks and a very large throughput of high hazard products, such arrangements were essential.

Shift changeover was inadequately structured, variable and informal. It was conducted face-to-face between supervisors but without an established and verifiable structure, and without consistent agreement on which key information to positively record. It was usually short (around 10 minutes).

Proportionate policy, standards or procedures for changeover had not been set. In the absence of such adequate formalisation within the safety management system (SMS): there were no verifiable performance standards or responsibilities set, or procedure(s) drawn up to implement suitable changeover arrangements; or against which to establish, assess, maintain and improve competency; or subsequently against which to check compliance; or to audit and monitor the arrangements within the SMS.

The key information required for communication at handover had not been adequately determined. The changeover arrangements were not adequately structured to reflect all of the key hazards and risks, including those from human error. Management had not set a clear high priority for this key, frequent and regular activity. All of this made shift communication and changeover at the terminal likely to be inconsistent, inadequate and prone to error.

Such arrangements as were in place were inadequate. The two handover logs and allied documents were largely generated by the supervisors themselves, based on custom and practice at the Buncefield site, and on earlier British Pipeline Authority documents. This did not represent end-user active and informed involvement based on good practice.

Changeover was heavily skewed towards the more active pipeline activities. The absence of an agreed and well-structured area on the pipeline handover log for the busiest of the pipelines was a key omission. While this reflected the traditionally largely reactive role that the site played in relation to this key major hazard activity, it did not adequately reflect the site's actual responsibilities for major accident control and prevention.

There were some elements of apparent good practice in place for changeover. For example, face-to-face communication at handover, use of handover logs, availability of the Automatic Tank Gauging (ATG) and SCADA system displays, use of written and verbal communication, and some advantages conferred by a 12-hour shift pattern (see below). *However, there was no supporting use of other key assurance elements, and in the absence of any clear agreement on what information was key for recording and transfer, was necessarily incomplete anyway.* For example: the pipeline handover log did not provide a transparent, balanced and proportionate picture of key major hazard activities; there was no requirement to formally review and agree the ATG and SCADA status at or close to handover or to review other key documents; and there were no arrangements in place for clarification, confirmation or repetition of key information.

The verbal passing on of information was seen as the default position i.e. rather than writing it down on the handover log, if time or events were pressing. Equally the supervisors tended to focus on information that they thought relevant to the following shift i.e. rather than considering longer-term information needs as well.

Any reduced alertness and increased fatigue resulting from the 12-hour shifts – particularly towards the end of such shifts – was exacerbated very significantly by other fatigue and shiftwork issues present at the terminal. Without effective changeover arrangements there was also an increased risk, despite some of the possible advantages of a 12-hour shift system (*HSE 2006b*), of incorrect or inadequate awareness of the pipeline/tank activities persisting across more than one shift, and this did in fact occur across some of the preceding changeovers.

There was also a compounding failure to identify the vulnerability of particular changeovers: The involvement of a relatively inexperienced supervisor in one of the preceding handovers (he had worked independently on-shift for only 6 weeks prior to the incident). Two key handovers took place on a Saturday when there was only a single supervisor on day shift covering both pipeline and terminal roles (and so handing over both). This sole supervisor was also working for the first time with a relatively new technician. Guidance identifies handovers between experienced and inexperienced staff as high risk (*HSE SH*).

There was an increased likelihood of error on the four preceding shift handovers. They all coincided with relatively busy periods of activity on the pipeline. Two took place on a busy Saturday for the sole supervisor; on those handovers the same supervisor was involved in handing over and then receiving back the handover. Key pipeline tasks requiring high levels of vigilance by the supervisors for periods of 30–40 minutes were carried out at or around the preceding handovers.

There were other significant shift communication and changeover failures. Key information was not communicated between shifts and maintenance management, and between shifts and operational management, about the operation and maintenance (including specialist contractor activity) of the ATG tank level gauges.

All of the above failures contributed significantly towards the accident. Key information was not reliably passed on at the handovers immediately beforehand resulting

in the supervisors not having adequate awareness of specific pipeline, tank and ullage activity. This resulted in on-going uncertainty and subsequent confusion. The particularly dynamic nature of pipeline, tank and ullage activity made it even more important that these activities were well understood, analysed and assessed, and the key information requirements identified for changeover, and arrangements made to assure their reliable communication, and to minimise the potential for human error. Those individuals involved in the changeovers preceding the accident were working within the norm for custom and practice at the terminal. All of this contributed significantly towards the mistaken picture (shared by those working in the control room on the night) of which pipeline was feeding which tank.

CONCLUSIONS & RECOMMENDATIONS

CONCLUSIONS FROM REVIEW OF OTHER SECTORS

There is good practice in other comparable sectors, some of which are further developed in this area: however the focus varies, application is limited and the research and guidance is usually developed from the Lardner and HSE sources.

In *aviation* most of the work is around air traffic control or aircraft maintenance both of which involve significantly different tasks and work environments. Aircraft maintenance is mainly task-focused, an area that is largely dealt with under permit/control of work arrangements on/offshore; ATC handovers are frequent – every hour and a half or so – and also have a very specific task focus. The more limited spacecraft literature is also helpful but refers back to the same basic research and sources.

The *nuclear* industry has good practice but there is very little information publicly available. Arrangements at more conventional nuclear facilities such as power stations are comparable (though well-developed), and practice is based on similar literature to offshore. The industry benchmarks mostly within its own sector.

The *Patient Safety* area is currently active on handover though mainly focused on ward handovers, and is itself seeking to learn from other sectors. The guidance available is based on similar literature with some later more sector-specific studies.

Onshore practice in the major hazard (COMAH) industries reflects a wider range of processes and activities, so that for example process complexity can be a factor differentiating practice from offshore. Onshore gas and oil terminals are probably the closest comparators but there are some unique aspects to the offshore situation such as tour arrangements, physical and environmental constraints, crew changes and the asset/shore divide.

While not specifically covered here the *shipping* sector is also now active in this area but sources such as (*Alert*) do not have specific information on handover as yet. However, it is part of good crew resource or bridge communication management. Shipping, spacecraft control, and other sectors are also very specialised, and refer back to the same basic literature and guidance.

Overall while some good practice elements can be taken from other sectors (see below) the best sources remain UK-based and are largely available through the materials on the HSE WebPages. These pages offer well-established guidance and tools and can be used, for example, to audit or review current arrangements. The first author is currently developing a more specific assessment tool for changeover incorporating all the good practice elements identified here.

BUNCEFIELD CONCLUSIONS

The Buncefield accident demonstrates again – after Piper Alpha and Texas City – that shift changeover and handover arrangements need to be effective and robust, and tailored for the specific major hazard activities under control. In other words the arrangements should adequately reflect the hazards and risk and the specific activities involved. Despite the many Buncefield reports (*via Buncefield 2005*), it would be helpful if a fuller narrative of the events leading up to the overfill were made available by HSE to emphasise this and other key human factor issues.

The main gap that the review and consideration of the Buncefield accident demonstrates is that while research and guidance on good practice is well-established and available now across a range of key sectors, including the major hazard sector, it is still not being implemented fully effectively. In other words it isn't more research or guidance that is required but effective implementation of existing well-established guidance.

Finally there is also an over-focus on shift-to-shift handover specifically and not on wider – but equally critical – within-shift and shift-to-days or shift-to-management communication issues. The Buncefield example shows this very clearly. There is also still a lack of appreciation that handover is only part of shift changeover, and that good preparation beforehand, and cross-checking afterwards are equally important. It is not an exaggeration to say that preparation for handover begins at shift start (*JSP 2008.*)

RECOMMENDATIONS

APPLICATION OF EXISTING GUIDANCE

The primary recommendation is that companies on and offshore make use of existing well-established guidance to review and if necessary reassess their own changeover arrangements. This paper is designed to provide a useful summary for review.

OFFSHORE-SPECIFIC RECOMMENDATIONS

The industry, in addition to the above recommendations should consider how to secure more consistent crew-change changeover; should recognise more explicitly that 12-hour shifts and extended same-person handovers can increase the likelihood of some error types e.g. mistakes; should continue to work on assuring good shift-shore communication; should review current procedures and related

arrangements for changeover to ensure they reflect guidance and good practice; should identify and secure higher risk handovers.

ADOPTING GOOD PRACTICE FROM OTHER SECTORS

Several specific good practice points were identified in the review above: (1) The use of memorable acronyms can be helpful for changeover e.g. the use of PRAWNS in air traffic control. These are best developed for specific sites or processes through assessment of information needs. (2) The checklist developed by Parkes and Mishkin (Annex 1) is a useful supplement to the HSE audit guide questions in assessing changeover arrangements. (3) The nuclear practice of holding a wider 'standing up' shift communication meeting with the on-coming shift after the specific handover period has taken place may be useful. (4) Making sure that changeover is emphasised as important by management and reflected proportionately in the procedures and arrangements for securing this.

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ANNEX 1 *(FROM PARKE & MISHKIN 2003)*

Checklist for effective shift handovers

The following check list contains additional best practices distilled from both the European and American literature cited earlier *[in their paper]*.

(1) Is sufficient schedule over-lap time and distraction-free space allocated for effective one-on-one, face-to-face shift handovers?

(2) Is sufficient time and distraction-free space allocated for necessary group handovers?

(3) Are handovers face-to-face, or if not, is there an opportunity for two-way communication regarding tasks, i.e., can questions be asked? For example, prior arrangements can be made to have questions answered via other technologies (phones or emails) or third parties.

(4) Is time allocated and are resources provided for the outgoing shift to prepare any handover material?
(5) Are the necessary information sources readily accessible to the incoming worker?
(6) Is time allocated and are resources provided to develop written support of handovers, such as structured shift handover worksheets with specific questions or a list of material to be covered?
(7) Was this written material developed with the input of those who will use it?
(8) Was the written material evaluated by the workers in a trial period with the opportunity to recommend additions and/or deletions?
(9) Does the written material have some blank fields for workers to describe unusual occurrences?
(10) Does the written material demand inclusion of relevant information as ascertained by worker input, critical incident analysis, and/or careful consideration of risks associated with not handing over the material in question?
(11) In both written and verbal descriptions of tasks and occurrences, is there an effort to capture problems, hypotheses, and intent, rather than simply listing what occurred?
(12) If there are multiple tasks or sources that must be reviewed before coming onto a shift, is there a check list to insure that all will be accomplished?
(13) Are the shift handover procedures written up?
(14) Are the shift handover procedures specifically trained?
(15) Are shift handovers periodically monitored?
(16) Is handing over known to be an equal responsibility of both incoming and outgoing worker?
(17) Is there an effort to promote a culture where communication mistakes are expected, and efforts are made to avoid them or mitigate their consequences when they occur? In this type of culture, phrases such as “Good catch!” are heard.
(18) Are workers alerted to the necessity for lengthier and more thorough handovers in abnormal operations, when either person is new at the job, and when the one taking over has been away from work for a few days?
(19) Are days off staggered in a team to preclude their all returning at once?
(20) Are computer databases, word processing programs, and other software tools used when possible to reduce handover workload?
(21) Are handover databases searchable?
(22) Are handovers seen not only as error-prone, but as sometimes potentially beneficial? Problems encountered in the first shift can be viewed by a second pair of experienced eyes and personnel from both shifts can engage in collaborative problem solving.

Shift handover is a crucial exercise with a direct influence on production and safety. Faulty shift handover is known to cause maintenance difficulties such as plant upsets, unplanned shutdowns and product rework, which can result in significant revenue decline. Analysis by one oil & gas business revealed that while start-up, shutdown and changeover times estimate for less than 5% of an operationâ€™s personnel time, 40% of plant events occur throughout this time.Â The Buncefield incident investigation team announced that adequate arrangements for shift handover were not in place and there was uncertainty between supervisors about which tank was being filled, and the shift logbook was only utilized to obtain data about one of the pipelines.